ENG.20050826.0001

QA: Q/A

000-3DR-MGR0-00100-000

Revision 005

August 2005

Project Design Criteria Document

Prepared for:

U.S. Department of Energy
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Office of Repository Development
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Under Contract Number
DE-AC28-01RW12101

DISCLAIMER

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7\. Remarks
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9. DI (Including Revision Number, if applicable):
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10. Revision No.	11. Description of Change
00	Initial Issue An impact review per AP-2.14Q, *Review of Technical Products and Data,* is not required because this is the initial issue of the Project Design Criteria Document.
01	The entire Project Design Criteria document is being revised (per Section 5.6 (2) of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria*) to incorporate additional design criteria, codes and standards, etc., that have been identified since the issuance of Revision 0. Changes from the previous issuance are not uniquely identified with change lines because the entire document has been revised. All revised sections are within the scope of preliminary design efforts necessary to support the license application. An impact review per AP-2.14Q, *Revision of Technical Products and Data,* was not performed because the providers of inputs and checkers of the Project Design Criteria Document, Revision 1, are from the same discipline organizations and comprised of personnel who would have participated in the AP-2.14Q review of the document (Section 5.3 of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria*), including those from a different discipline or functional organization. Any organization potentially affected by the Project Design Criteria Document is included in the checking and review process and this checking and review process essentially included aspects of an impact review per AP-2.14Q. An interdisciplinary review per Section 5.3.2 of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria,* was not performed because the disciplines/organizations (that are outside the Repository Design Project organization) providing the input were included as a part of the discipline checking and review performed in accordance with Section 5.3.1 of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria.* ES&H and Public Address organizations, which are external to Repository Design Project, were included in Block #5 as Checkers but were not included in Block #7 as Engineering Group Supervisors/Discipline Lead Engineer.
02	The Project Design Criteria Document is being updated to include design criteria that have been revised to conform to the evolving design. Sections 4, 5 and 6 have extensive changes which include changes to codes and standards lists, editorial changes including re-numbering of sections, re-numbering the criteria, updating the references wherever appropriate. Section 1 has minor changes to reflect the current state of the design. Section 7 has extensive changes to update the documents and codes and standards that have been updated or deleted from the previous revision. Appendix A has been revised to provide an updated licensing position on the regulatory guides listed. Specifically, changes occurring in the following pages: 1-3, 5-7, 9-11, 13-358 and all of Appendices A and B.
003	This revision of the Project Design Criteria is focused on aligning information in the Project Design Criteria with the License Application Safety Analysis Report. Updated information has been included in various sections as marked by the change bar. – Sections 5.2.1, 5.5.1, and 5.7.1 were revised to correct the version of ASME NQA-1-2000 [DIRS 159544] that defines the requirements for cleaning and packaging, shipping, storage, and handling of items (Condition Report 3366). – The source for track layout information in Section 4.2.1.3.3 and thermal goals in 6.3 is being tracked by TBV (Condition Report 3507). – References to Regulatory Guide 8.8 were added (Condition Report 2582). This is a complete revision. Change bars indicate the changes and all pages are affected in this complete revision.
004	This revision addresses technical direction for Design and Engineering in "Contract No. DE-AC28-01RW12101 - Response to Contracting Officer Authorization Letter No. 05-001, Improvements and Refinements in the Technical Bases that Support the Safety Analysis Report (SAR)" (Mitchell 2005 [DIRS 173265]), which includes the aging system, first-of-a-kind important to safety equipment, waste package transporter, waste package emplacement gantry, remediation, throughput models, fire protection in moderator control areas, and thermal management (waste package and drift loading plans) and changes to codes and standards. Commercial spent nuclear fuel in air will be addressed in a later revision. Additionally, minor corrections were made to content. Sections 4.9.1.1 and 4.9.1.5 were revised to correct the version of ANSI/ANS-6.1.1 to 1977 in response to Condition Report Action Number 4306-002. Section 4.6.4.29 was modified to provide rationale for the requirement for instrumentation grade air to be oil free in response to Condition Report 5175. This is a complete revision. Change bars in the margin indicate the changes and pages iii-v, 1–3, 5–7, 9–11, 13, 15–18, 20–55, 57, 60–100, 102–122, 124–126, 128–158, 161–166, 172–191, 193-194, 199, 201–204, 206–218, 220–260, 262–329, 330–349, 351, 353–360, 361, 363–387, 389–395, A-3, A-5–A-24, A-26–A-32, A-34–A-46, B-3 are affected in this revision.
005	This revision is required to ensure alignment of the PDC with recently revised system description documents, facility description documents, and the safety analysis report. Changes were also made to add additional regulatory documents that apply. Section 4.8.4.5 was added to identify criteria regarding Management of Loose Radioactive materials to address issues associated with Condition Report 5929. Organizational responsibilities have also been updated.

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1. INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of the Project Design Criteria (PDC) document is to provide the design criteria necessary to support the development of preliminary and detailed design for all repository structures, systems, and components (SSCs). The PDC satisfies requirement PRD-022/P-001 of *Project Requirements Document* (hereinafter referred to as the PRD) (Canori and Leitner 2003 [DIRS 166275]), which requires that all repository SSCs shall be designed in accordance with applicable industry codes, standards, engineering principles, and practices. The scope of the PDC includes general discipline design criteria, codes and standards, regulations, design acceptance limits, design load cases, and some design load combinations. The PDC identifies the appropriate codes and standards for SSCs that are associated with safety categories (items important to safety [ITS] and important to waste isolation [ITWI]) determined from *Q-List* (BSC 2005 [DIRS 174269]). As the design evolves, the PDC will be revised in accordance with the evolving design and safety categories provided in *Q-List* (BSC 2005 [DIRS 174269]) for repository systems.

The PDC is organized along traditional discipline lines and comprised of sections that contain general design criteria or generic discipline design criteria, design load combinations, site conditions, and data sheets containing applicable codes and standards for each discipline in Engineering.

The PDC provides constraints to the design in the form of applicable codes, standards, and regulatory guidance positions. See *Requirements Management Program* (BSC 2005 [DIRS 174516], Figure 1, Section 4.1) for an explanation of the requirements management program flowdown.

1.2 EFFECTIVE DATE

The U.S. Nuclear Regulatory Commission (NRC) requires, in 10 CFR 63.21(c)(2), Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada [DIRS 173273], that the Safety Analysis Report include information relative to codes and standards that the U.S. Department of Energy (DOE) proposes to apply to the design and construction of the geologic repository operations area (GROA). Design engineers will use the codes, standards, regulatory guides, and NRC technical report designation (Nuclear Regulatory Commission) (NUREGs) stated in this document. Changes to those documents used herein after the initial issue (Rev 000) date of this document will be addressed, as necessary, in future revisions during the design process and will be approved by the Engineering Manager.

1.3 REGULATORY GUIDANCE DOCUMENT APPLICABILITY

NRC regulatory guidance documents, such as regulatory guides and U.S. Nuclear Regulatory Commission Technical Reports (NUREGs), are generally written by the NRC to provide applicants and licensees with information such as methods acceptable to the NRC for meeting specific parts of the NRC regulations, methods used by the staff in evaluating specific problems or postulated accidents, and data needed by the NRC in its review of applications for permits and licenses. Regulatory guides are not substitutes for regulations, and compliance with them is not required.

The supplementary information for the 10 CFR 63 final rule publication (66 FR 55732 [DIRS 156671]) (specifically in the comments on Preclosure Safety Analysis, 66 FR 55742) states that "the applicability of regulatory guidance developed for facilities other than a high-level waste repository will need to be considered on a case-by-case basis for applicability to high-level waste disposal at the Yucca Mountain. For the guidance to be appropriate, it should be generally applicable to nuclear facilities with comparable or higher risks to workers and the public than the potential repository at Yucca Mountain site."

The selection of regulatory guides and NUREGs provided in Appendix A is based on applicability to support the development of design products. Although regulatory guides are written for other NRC licensed activities, the Office of Repository Development (ORD) will conform to those identified in Appendix A, as applicable, in the development of design products. Since 10 CFR Part 63 [DIRS 173273] governs, the ORD takes generic exception where regulatory guidance documents invoke criteria to comply with the specific requirements of 10 CFR Part 50, Energy: Domestic Licensing of Production and Utilization Facilities [DIRS 165855] where 10 CFR Part 63 does not itself invoke 10 CFR Part 50. These exceptions are detailed in Appendix A, where applicable.

1.4 U.S. DEPARTMENT OF ENERGY DIRECTIVES APPLICABILITY

DOE HQ O 250.1-1998, *Civilian Radioactive Waste Management Facilities—Exemption from Departmental Directives* (DOE 1998 [DIRS 159140]), provides for the exemption of Office of Civilian Radioactive Waste Management (OCRWM) facilities from certain DOE directives. The exemption applies to DOE directives that overlap or duplicate requirements of the NRC regarding radiation protection, nuclear safety (ITS and ITWI for the Yucca Mountain Project [YMP]) (including quality assurance), and safeguards and security of nuclear material in the design, construction, operation, and decommissioning of radioactive waste (OCRWM) facilities. Exemptions apply to requirements in directives that overlap or duplicate NRC requirements and ensure the precedence of NRC requirements. Table A-2 lists applicable DOE directives. Appendix B provides technical positions for regulatory guidance documents and codes and standards cited in the *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274]) that have not been accepted by the ORD.

OCRWM facilities include structures, equipment, systems, processes, or activities associated with the acceptance, transportation, storage, and disposal of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) pursuant to the Nuclear Waste Policy Act of 1982 [DIRS 101681], and NRC regulations, where applicable. Examples include interim storage structures and technologies, repository facility structures, and waste acceptance and transportation activities.

Exemptions do not apply to requirements for which the NRC defers to the DOE or does not exercise regulatory jurisdiction.

DOE directives that provide criteria applicable to the non-nuclear portion of the repository facility will be addressed per the Bechtel SAIC Company (BSC) contract.

1.5 NATIONAL CODES AND STANDARDS APPLICABILITY

DOE O 252.1-1999, *Technical Standards Program* [DIRS 159139], requires the use of voluntary consensus standards by the DOE in a manner consistent with National Technology Transfer and Advancement Act of 1995, Public Law 104-113 [DIRS 159251], and OMB Circular No. A-119, *Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities* [DIRS 159250]. Public Law 104-113 [DIRS 159251] allows an agency to take exception to specific portions of a voluntary consensus standard if those provisions are deemed to be inconsistent with applicable law or otherwise impractical.

Consensus standards are the product of a Standards Developing Organization operating with openness, balance of interests, due process, an appeals process, and consensus that represents general agreement but not necessarily unanimity.

The integration of national codes and standards into the NRC regulatory process is achieved through: (a) incorporation of codes and standards by reference in regulations; (b) endorsement of codes and standards in regulatory guides as acceptable methods for implementing regulation; and (c) referencing of codes and standards as a technical basis in Standard Review Plans, Technical Specifications, Generic Communications, and Inspection Manuals. Although (a) is the prime example of a mandatory requirement, (b) and (c) are the primary mechanisms for allowing voluntary use of consensus standards by licensees.

Regulation 10 CFR Part 63 [DIRS 173273] does not provide prescriptive design criteria; instead it allows the DOE to develop design criteria and demonstrate their appropriateness. Therefore, the DOE has flexibility to use any codes, standards, and methodologies it demonstrates to be applicable and appropriate in repository design.

When codes or standards are in conflict with each other, the specific issue will be presented to the appropriate manager for resolution.

1.6 QUALITY ASSURANCE

The PDC is written in accordance with LP-3.25Q-BSC, *Design Criteria,* and is subject to the requirements of *Quality Assurance Requirements and Description* (hereinafter referred to as the QARD) (DOE 2004 [DIRS 171539]).

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2. ACRONYMS AND ABBREVIATIONS

AC	alternating current
ACGIH	American Conference of Governmental Industrial Hygienists
ALARA	as low as is reasonably achievable
ANSI	American National Standards Institute
ARM	area radiation monitor
ASCE	American Society of Civil Engineers
ASD	allowable stress design
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
BDBGM	beyond design basis ground motion
BOP	balance of plant
BSC	Bechtel SAIC Company
BTU	British thermal unit
CAM	continuous air monitor
CCCF	Central Control Center Facility
CCTV	closed circuit television
CFR	Code of Federal Regulations
CHF	Canister Handling Facility
CSNF	commercial spent nuclear fuel
DBGM	design basis ground motion
DC	direct current
DCMIS	digital control and management information system
DOE	U.S. Department of Energy
DTF	Dry Transfer Facility
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EPA	U.S. Environmental Protection Agency
ES&H	Environmental Safety and Health
FHF	Fuel Handling Facility
F&OR	*Project Functional and Operational Requirements*
FAA	Federal Aviation Administration
GROA	geologic repository operations area
HEPA	high-efficiency particulate air
HLW	high-level radioactive waste
HVAC	heating, ventilation, and air-conditioning

ACRONYMS AND ABBREVIATIONS (Continued)

I&C	instrumentation and control
IBC	International Building Code
ICEA	Insulated Cable Engineers Association
ITS	important to safety
ITWI	important to waste isolation
LAN	local area networking
LLW	low-level radioactive waste
LWR	light water reactor
M&O	Management and Operating Contractor
MPEG	Motion Picture Experts Group
MSC	monitored geologic repository site-specific cask
MSHA	Federal Mine Safety and Health Act
NAC	Nevada Administrative Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
non-SC	non-safety category
NPT	National (American) Standard Pipe Taper
NRC	U.S. Nuclear Regulatory Commission
NUREG	NRC technical report designation (Nuclear Regulatory Commission)
OCRWM	Office of Civilian Radioactive Waste Management
ORD	Office of Repository Development
OSHA	Occupational Safety and Health Administration
PAA	Project Accumulation Area
PSA	preclosure safety analysis
PDC	*Project Design Criteria Document*
PRD	*Project Requirements Document*
PVC	polyvinyl chloride
QARD	*Quality Assurance Requirements and Description*
RCRA	Resource Conservation and Recovery Act of 1976
RFI	radio frequency interference
RRM	radiation/radiological monitoring
RTD	resistance temperature detector
RWP	radiation work permit
SAA	Satellite Accumulation Area
SC	safety category
SNF	spent nuclear fuel
SNM	special nuclear material
SONET	Synchronous Optical Network
SRSS	square root of the sum of the squares

ACRONYMS AND ABBREVIATIONS (Continued)

SSCs	structures, systems, and components
SSE	safe shutdown earthquake
STC	sound transmission class
TEDE	total effective dose equivalent
TLV	Threshold Limit Value
TNT	trinitrotoluene
TSPA	Total System Performance Assessment
UL	Underwriters Laboratory
UPS	uninterruptible power supply
VAC	volts of alternating current
VDC	volts of direct current
WP	waste package
WSMO	Weather Service Meteorological Observatory
YMP	Yucca Mountain Project

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3. DEFINITIONS

3.1 *Design*—Specifications, drawings, criteria, and performance requirements. Also, the result of deliberate planning (e.g., feasibility studies), analysis (e.g., hazard and risk assessment, performance assessment), mathematical manipulation (e.g., sensitivity studies), and design processes (e.g., independent design review).

3.2 Not Used

3.3 *Design Bases (10 CFR 63.2 [DIRS 173273])*—Means that information that identifies specific functions to be performed by a system, structure, or component of a facility and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be constraints derived from generally accepted "state-of-the-art" practices for achieving functional goals or requirements derived from analysis (based on calculation or experiments) of the effects of a postulated event under which a system, structure, or component must meet its functional goals. The values for controlling parameters for external events include:

1. Estimates of severe natural events to be used for deriving design bases that will be based on consideration of historical data on the associated parameters, physical data, or analysis of upper limits of the physical processes involved; and

2. Estimates of severe external human-induced events to be used for deriving design bases that will be based on the analysis of human activity in the region, taking into account the site characteristics and risks associated with the event.

3.4 *Design Criteria*—Standards, codes, laws, regulations, general discipline design criteria, event sequences, and hazards that shall be used as a basis for acceptance of design for SSCs to satisfy requirements.

3.5 *Design Input*—The criteria, parameters, bases, or other design requirements upon which design output documents are based.

3.6 *Design Output*—Drawings, specifications, and other design documents prepared to present the design configuration(s) of SSCs that is supported by design inputs.

3.7 *Design Requirement*—Engineering technical requirements, determined by design processes, that define, for example, the functions, capabilities, capacities, physical size, configurations, dimensions, performance parameters, limits, and setpoints, and are developed and specified by the design authority for SSCs to satisfy the mission design input requirements. Detail design requirements are the result (often iterative) of the design processes.

3.8 *Design Verification*—Documented, traceable measures (e.g., design review, alternate calculation, and qualification testing) applied to a design package or technical output by qualified individuals or groups other than those who performed the original design work. These measures verify the technical validity, adequacy, and completeness of a design package or technical output in context with the total design, natural or engineered barrier system, or integrated technical work.

3.9 *Geologic Repository Operations Area (GROA) (10 CFR 63.2 [DIRS 173273])*—Means a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

3.10 *Important to Safety (10 CFR 63.2 [DIRS 173273])*—With reference to structures, systems, and components, means those engineered features of the geologic repository operations area whose function is:

1. To provide reasonable assurance that high-level waste can be received, handled, packaged, stored, emplaced, and retrieved without exceeding the requirements of 10 CFR 63.111(b)(1) for Category 1 event sequences; or

2. To prevent or mitigate Category 2 event sequences that could result in radiological exposures exceeding the values specified at 10 CFR 63.111(b)(2) to any individual located on or beyond any point on the boundary of the site.

3.11 *Important to Waste Isolation (10 CFR 63.2 [DIRS 173273])*—With reference to design of the engineered barrier system and characterization of natural barriers, means those engineered and natural barriers whose function is to provide a reasonable expectation that high-level waste can be disposed without exceeding the requirements of 10 CFR 63.113(b)(c).

3.12 *Licensing Basis*—The current effective regulatory requirements imposed on the facility, including the requirements at the time the initial license was applied for and granted, together with requirements subsequently imposed. The licensing basis is presented in the Safety Analysis Report and other docketed licensee correspondence.

3.13 *Margin*—The difference between the calculated expected value event sequence dose and the prescribed regulatory limit.

3.14 *Mission/Regulatory Requirements*—Input design demands requested by the owner or client (or imposed by statute or regulation) that identify and define design requirements for performance; functional, operational, and maintenance characteristics; or parameters that the facility SSCs are to be designed to satisfy.

3.15 *Non-Safety Category (non-SC)*—SSCs not credited for compliance to the performance objectives in 10 CFR 63.111 [DIRS 173273] and natural/engineered barriers that are not important to meeting the performance objectives in 10 CFR 63.113.

3.16 ***Postclosure***—The period of time after permanent closure of the repository system.

3.17 ***Preclosure***—The period of time prior to permanent closure of the repository system.

3.18 ***Preclosure Safety Analysis (PSA) (10 CFR 63.2 [DIRS 173273])***—Means a systematic examination of the site; the design; and the potential hazards, initiating eventsand event sequences and their consequences (e.g., radiological exposures to workers and the public). The analysis identifies structures, systems, and components important to safety.

3.19 ***Safety Category (SC)***—SSCs that are credited for the prevention or mitigation of Category 1 and Category 2 event sequences so they meet the performance objectives in 10 CFR 63.111 and natural or engineered barriers that are important to meeting the performance objectives in 10 CFR 63.113 [DIRS 173273].

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4. FACILITY DESIGN CRITERIA

4.1 GENERAL DESIGN CRITERIA

4.1.1 Generic Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
General	Generic[b]	ANSI Z535.1-1998, ANSI Z535.2-1998, ANSI Z535.3-2002, ANSI Z535.4-1998, ANSI Z535.5-1998, ANSI/ASHRAE 55(55a)-1995, ANSI/ASHRAE 62.1-2004, ANSI/ASHRAE/IESNA Std 90.1-2004, ASHRAE 2001, ASHRAE 2003, NEMA MG 1-1998, NEMA MG 10-1994, NEMA MG 11-1977 (R199, R2001), SMACNA 1985, SMACNA 1995
		None
		10 CFR Part 430, 10 CFR Part 434, 10 CFR Part 436, 63 FR 49643 (Executive Order 13101), 64 FR 30851 (Executive Order 13123), 66 FR 40571 (Executive Order 13221)
		DOE O 413.3, DOE O 430.2A, DOE O 450.1

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022/P-001. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] None.

[3] Addressing CFRs supports compliance with requirements in PRD-021/P-001 and PRD-022/P-001.

[4] Addressing these DOE directives supports compliance with the requirements of PRD-018/P-021. Applicable sections of these DOE directives will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.1.1.1 Energy Conservation Compliance

Criteria—Each of the repository facilities shall be designed with the goal of reducing water and energy consumption per gross square foot through life cycle cost-effective measures. Use the U.S. Environmental Protection Agency (EPA) Energy Star and DOE Federal Energy Management Program energy and water efficient appliance and equipment requirements.

Technical Rationale—This criterion ensures compliance with 10 CFR Part 434, Energy: Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings [DIRS 158912], that provides the minimum standards for energy efficiency in the design of new federal buildings. This document provides design requirements for building envelopes, electrical distribution systems, and equipment for electric power, lighting, heating, ventilation, air-conditioning, service water heating, and energy management. This is also in conformance with 64 FR 30851 [DIRS 104026], Executive Order 13123, that provides the goals for reducing greenhouse gas emissions attributed to energy use in federal buildings.

4.1.1.2 Design Conditions

Criteria—The ambient (outdoor) and indoor design conditions, as required in Section 4.8.2, shall be used in energy conservation calculations.

Technical Rationale—This criterion is based on the applicable comfort criteria in ANSI/ASHRAE Std 55-2004, *Thermal Environmental Conditions for Human Occupancy* [DIRS 174322], and 10 CFR Part 434 [DIRS 158912], Subpart C. The requirements in Section 4.8.2 are not intended to be all-inclusive and additional data may be obtained from qualified sources to implement the requirement of the Energy Conservation Program.

4.1.1.3 Prescriptive/System Performance Compliance Alternative

Criteria—Each facility of the repository shall comply with the requirements shown in Table 4.1.1-1 to evaluate the energy efficiency of any building and associated energy-using system to meet the water conservation and energy efficiency goals. This alternative compliance method shall be used where a minimum amount of calculation is required to show compliance with the energy conservation requirements.

Table 4.1.1-1. Compliance Minimum Requirements

Minimum Requirement System Description	General Compliance[a]	Mandatory Requirements[a]	Minimum Requirements[b]
Electrical Distribution System	Section 8.1	Section 8.2	Section 434.401.1
Electric Motors	Section 10.1	Section 10.2	Section 434.401.2
Lighting	Section 9.1	Section 9.2	Section 434.401.3
Building Envelope	Section 5.1	Section 5.2	Section 434.402
HVAC Equipment	Section 6.1	Section 6.2	Section 434.403.1
HVAC Systems	Section 6.1	Section 6.2	Section 434.403.2
Service Water Heating Systems	Section 7.1	Section 7.2	Section 434.404

NOTES: [a] ANSI/ASHRAE/IESNA Std 90.1-2004 [DIRS 174321].
[b] 10 CFR Part 434 [DIRS 158912].

Technical Rationale—This criterion is in conformance with 10 CFR Part 434 [DIRS 158912], Subpart D; 10 CFR Part 430, Energy: Conservation Program for Consumer Products [DIRS 168928], Subpart C; and ANSI/ASHRAE/IESNA Std 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321].

4.1.1.4 Building Energy Cost Compliance Alternative

Criteria—The building energy cost compliance alternative method shall be used where greater flexibility is required in the design of energy efficient buildings using an annual energy cost method. The annual design energy cost of the proposed building shall be less than or equal to the annual energy cost budget of a prototype or reference building.

Technical Rationale—This criterion provides an alternative compliance path using the annual energy cost method in accordance with 10 CFR Part 434 [DIRS 158912], Subpart E, and ANSI/ASHRAE/IESNA Std 90.1-2004 [DIRS 174321], Section 11. It uses energy costs (dollars) to determine compliance rather than units of energy or power, such as British thermal units (BTUs), kilowatt-hour, or kilowatt, and allows the energy use contribution of different fuel sources at different times to be added and compared. This method allows for innovation in designs, materials, and equipment, such as passive solar heating, heat recovery, better zonal temperature control, thermal storage, and other applications of off-peak electrical energy that cannot be adequately evaluated by using other alternative methods.

4.1.1.5 Building Energy Use Compliance Alternative

Criteria—The building energy cost compliance alternative method shall be used where greater flexibility is required in the design of energy efficient buildings using an annual energy use method. With this method, a life cycle cost analysis shall be performed of major fuel alternatives and the one with the lowest life cycle cost shall be used in the calculation. The annual Design Energy Use of the proposed building shall be less than or equal to the calculated annual Energy Use Budget of a prototype or reference building.

Technical Rationale—This criterion provides an alternative compliance path using the annual energy use method in accordance with 10 CFR Part 434 [DIRS 158912], Subpart F. The life cycle cost criteria is in accordance with 10 CFR Part 436, Energy: Federal Energy Management and Planning Programs [DIRS 168930], Subpart A. This alternative method is similar to the building energy cost compliance alternative method. The principal difference is that the unit for comparing performance is BTUs of energy use instead of dollars of operating cost.

4.1.1.6 Energy Efficiency/Sustainable Design Report

Criteria—An energy efficiency/sustainable design report prepared for each building at the end of each design phase of the project shall demonstrate that the design complies with the executive orders, federal regulations, and sustainable design principles for energy efficiency. A performance test report shall also be prepared during the operation phase of the facilities. New buildings where total energy consumption is expected to exceed 500 million BTUs per year or a building larger than 10,000 gross sq ft shall have a certificate of compliance. A performance test during the operation phase shall demonstrate progress towards meeting energy costs and consumption goals, and the greening of the government through efficient energy management.

Technical Rationale—This criterion complies with DOE O 430.2A [DIRS 158913]. DOE O 430.2A requires the design report be submitted at the end of Title II.

4.1.1.7 Application for Waiver or Exemption

Criteria—Exemptions from the requirements of the executive orders and federal regulation for energy efficiency shall be obtained by submitting an Application for Exemption to the In-House DOE Energy Management Coordinator for evaluation and approval.

Technical Rationale—This criterion is in accordance with DOE O 430.2A [DIRS 158913] and 64 FR 30851 (Executive Order 13123), Greening the Government Through Efficient Energy Management [DIRS 104026], that provides the goals for reduction of greenhouse gas emissions attributed to the energy use of the federal buildings. DOE O 430.2A requires the design report be submitted at the end of Title II.

4.1.1.8 Waste Prevention, Recycling, and Federal Acquisition

Criteria—The repository shall incorporate waste prevention, pollution prevention, recycling, and federal acquisition into the daily operation of facilities.

Technical Rationale—This criterion is required to conform with the requirements of 63 FR 49643 (Executive Order 13101), Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition [DIRS 104024]; 64 FR 30851 (Executive Order 13123) [DIRS 104026]; and 64 FR 44639 (Executive Order 13134), Developing and Promoting Biobased Products and Bioenergy [DIRS 170198], that provide the goals for solid waste prevention or diversion and recycling, procurement of materials that are made with recovered or recycled materials, and use of environmentally preferable products and services.

4.1.1.9 Environmental Protection

Criteria—The repository shall be designed with pollution prevention systems to control air emissions and effluents, minimize water use, and reduce or eliminate discharges to the environment.

Technical Rationale—DOE O 450.1, *Environmental Protection Program* [DIRS 161567], establishes DOE policy to conduct its operations in an environmentally safe and sound manner and perform its activities in compliance with applicable environmental protection requirements. Facility design shall comply with applicable environmental requirements set forth by federal and state regulations, executive orders, and DOE directives, and requirements derived from environmental permits and corresponding permit conditions.

Design criteria derived from the federal and state environmental regulations and permit requirements have been incorporated into the appropriate section of this PDC. Additional design criteria will be added to the various sections of this PDC as permits for repository facilities are obtained.

General requirements that apply to several parts of the design are included in this section.

4.1.1.9.1 Water Use

General Environmental Design Criteria—Facilities shall be designed not to exceed a combined total water use of 430 acre-ft/yr as required by the water appropriations permits. Facility water use for preclosure, postclosure, and construction shall consider dust control, work underground, ongoing scientific, transportation, engineering studies, operational use, and construction requirements.

Technical Rationale—DOE applications 63263 through 63267 for Permits to Appropriate the Public Waters of the State of Nevada were submitted to the State Engineer in 1997 for a total of 430 acre-feet annually (Dixon 1997 [DIRS 170737]; Dixon 1997 [DIRS 170738]; Dixon 1997 [DIRS 170739]; Dixon 1997 [DIRS 170740]; Dixon 1997 [DIRS 170741]). The combined total duty of all five applications to appropriate groundwater shall not exceed 430 acre-feet annually. Facility water needs must be balanced against other identified uses (BSC 2004 [DIRS 172358]).

4.1.1.9.2 Wastewater

Criteria—Wastewater shall be controlled such that the repository operates as a zero discharge process. Wastewater is defined and segregated as two types depending on the source: industrial and nonhazardous oily wastewater.

- Industrial wastewater includes blowdown water from the cooling tower, regeneration water from the water softening system, water from the deionization system, and fire water runoff. Industrial wastewater is collected in evaporation basins or ponds. Evaporation ponds shall be lined with a material compatible with the wastewater that flows into the pond. Evaporation ponds are sized to accommodate all flows with zero discharge.

  NOTE: Industrial wastewater that may be contaminated by a radiological source is to be treated as suspect waste and should be segregated from other waste until a determination has been made. After waste categorization, handle as appropriate for that waste type.

- Oil-contaminated wastewater generated at the subsurface and surface facilities shall be collected and processed to prevent the pollution of water drainage systems and evaporation ponds.

Wastewater ponds shall be lined. The type of liner is to be compatible with the wastewater type. Additional design requirements for wastewater ponds may be imposed after discussions with the State of Nevada. Surface basins will need to be permitted under the underground injection control permit or a national pollutant discharge elimination system permit for zero discharge.

Technical Rationale—Based on Nevada underground injection control (NAC 445A.810 to 445A.925 [DIRS 104040]) and water pollution control regulations (NAC 445A.070 to 445A.348 [DIRS 104040]).

4.1.1.9.3 Sanitary Wastewater

Criteria—Sanitary sewage shall be disposed in appropriate systems at the North and South Portal pads or North Construction Portal, as required. The sanitary sewage system and infrastructure shall provide adequate storage for collection of wastewater as discussed in Section 4.2.1.3.5.

Technical Rationale—Based on NAC 444, *Sanitation* [DIRS 104039], water pollution control (NAC 445A.070 to 445A.348 [DIRS 104040]), and underground injection control (NAC 445A.810 to 445A.925 [DIRS 104040]) regulations.

4.1.1.9.4 Air Emission

Criteria—The repository shall be designed such that air emissions are minimized and the release of criteria pollutants and fugitive dust meets the limits identified by the EPA and State of Nevada.

Technical Rationale—NAC 445B, Air Controls [DIRS 104041].

4.2 CIVIL/STRUCTURAL/ARCHITECTURAL DESIGN CRITERIA

4.2.1 Civil Design Criteria

4.2.1.1 Civil Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Civil/Structural/ Architectural	Civil[b]	ANSI/AWWA D100-96-1997, AREMA 2002, ASCE 1991, AWWA 1990, ICC 2000 [DIRS 159179], ICC/ANSI A117.1-1998, NAC 445A, NAC 445B, NFPA 22-2003, NFPA 24-2002, NFPA 418-2001, NFPA 70-2004, ASCE 7-98
		Regulatory Guide 1.102, Regulatory Guide 1.59
		10 CFR Part 63, 28 CFR Part 36, 29 CFR Part 1926, 40 CFR Part 122
		DOE O 420.1A

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), and PRD-022 for all the civil SSCs within the GROA. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides. Addressing these regulatory guides supports compliance with requirements for all the civil SSCs within the GROA.

[3] Addressing CFRs supports compliance with requirements for all the civil SSCs within the GROA, PRD-015/P-015, PRD-015/P-020, PRD-015/P-021, and PRD-005.

[4] Addressing the DOE order supports compliance with requirements of PRD-018/P-019. Applicable sections of this DOE order will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.2.1.2 Site Development

4.2.1.2.1 Site Description

The repository at Yucca Mountain is located approximately 100 miles northwest of Las Vegas, Nevada. The repository surface facilities are located in distinct operational areas, namely:

- North Portal Operations Area
- South Portal Development Operations Area
- Ventilation Shafts Surface Operations Areas
- North Construction Portal.

Williams (2002 [DIRS 161090]) addresses the site development plan for the repository, which incorporates the necessary civil engineering features and arrangement required to support the surface repository facilities and systems for safe and efficient operations. The site layout is organized around the subsurface accesses and is configured considering owner and radiological exposure boundaries, flood/fault zones, topographic features, and meteorological patterns. In addition, it supports surface and subsurface operations and the required facility and transportation arrangements.

The site layout is designed to maximize preclosure radiological safety and to deter postclosure human disturbance of the repository. The site layout is also designed to limit impacts to the waste handling operations caused by worst-case environmental conditions.

4.2.1.2.2 Surveys and Datum

Criteria—Design documents shall provide for the following:

- Site boundaries
- Site grade
- Datum elevation
- Coordinates (NOTE: Coordinate data should correspond to the Nevada State Plane Coordinate System, Central Zone [NAD 27] for horizontal and NGVD 29 for vertical)
- Coordinates and elevations of the four operational areas (Section 4.2.1.2.1) will be given in a revision
- Survey control points
- Grid north based on the Nevada State Plane Coordinate System.

Technical Rationale—The information presented is required for site description by good engineering practice and shall conform to Nevada State Plane Coordinate System, Central Zone [NAD 27] for horizontal and NGVD 29 for vertical. These data have been used for all previous surveys.

4.2.1.2.3 Subsurface Investigations

Criteria—The surface facility design shall be based on the subsurface investigation for the repository compiled in *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project* (BSC 2002 [DIRS 157829]).

Technical Rationale—As stated, the information obtained for the subsurface investigations for the repository has been compiled in BSC (2002 [DIRS 157829]). Therefore, it shall be used for this document.

4.2.1.2.4 Site Design Parameters

Criteria

- Soil Properties—The soil properties are defined in BSC (2002 [DIRS 157829]); *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002 [DIRS 159262]); and *Supplemental Soils Report* (BSC 2004 [DIRS 166067]).

- Soil Bearing Capacity—The soil bearing capacity is defined in BSC (2002 [DIRS 159262]) and BSC (2004 [DIRS 166067]).

- Groundwater—The groundwater table is located at a typical depth of 1,270 ft below present ground surface and is over 1,000 ft below the top of bedrock in the North Portal area. Thus, groundwater is not a factor in geotechnical calculations (BSC 2002 [DIRS 159262]; BSC 2004 [DIRS 166067]).

- Flood—Flooding and wave action consequences associated with flooding events shall be identified in *Hydrologic Engineering Studies for the North Portal Pad and Vicinity* (BSC 2004 [DIRS 169464]).

- Frost Depth—The depth of frost penetration for foundation design is given in Section 6.1.1.7.

- Wind and Tornado—Wind load and tornado load design requirements are presented in Sections 4.2.2.3.6 and 4.2.2.3.7.

- Seismic—Seismic design load requirements are presented in Section 4.2.2.3.8.

- Environmental Condition—The design shall provide for the ability to withstand and operate in an extreme outside temperature environment (Section 6.1.1.5).

- Precipitation—Design basis precipitation is presented in Section 6.1.1.1.2.

Technical Rationale—The technical parameters are defined in BSC (2002 [DIRS 157829]), BSC (2004 [DIRS 169464]), BSC (2002 [DIRS 159262]), BSC (2004 [DIRS 166067]), and in Sections 4.2.2.3.6, 4.2.2.3.7, 4.2.2.3.8, 6.1.1.1, 6.1.1.1.1, 6.1.1.5, and 6.1.1.7.

4.2.1.2.5 Site Layout

Criteria—The site layout shall define the general conceptual layout of the repository systems defined by the following three drawings:

- *Overall Monitored Geologic Repository Layout* (BSC 2004 [DIRS 172171])
- *Geological Repository Operations Area North Portal Site Plan* (BSC 2004 [DIRS 171816])
- Geologic Repository Operations Area Aging Site Plan (BSC 2004 [DIRS 168740]).

Technical Rationale—The general conceptual layout of the repository systems/facilities are identified in the drawings listed above.

4.2.1.2.6 Site Drainage

Criteria—The configuration and grading of pads shall be designed to prevent the pooling of water.

- Site drainage shall protect the ramp, ramp portal, shaft, and shaft collar areas from water inflow as a result of the probable maximum flood.
- Site drainage shall contain and route stormwater from natural surface water drainage ways around surface facilities and provide water drainage for systems located on pads.
- Site drainage shall be designed for the runoff accumulated from the storms identified in Section 6.1.1.1.2.

Technical Rationale—Good engineering practice dictates the protection of facilities from probable maximum flood and runoff accumulations.

4.2.1.2.7 Site Slopes and Grades

Criteria

- The nominal grades within pad areas shall be as required to provide proper drainage.
- Fill slopes shall be designed with a slope value no steeper than two horizontal to one vertical.
- The system shall provide for worker safety and maintenance in accordance with 29 CFR Part 1926, Labor: Safety and Health Regulations for Construction [DIRS 172710].

Technical Rationale—Good engineering practice dictates proper drainage as well as practical slope requirements. Safety in construction must conform to federal safety standards.

4.2.1.2.8 Site Barriers

Criteria

- Two separated barriers (required to support safeguards and security) shall be located along the perimeter of each protected area.

- Physical barriers for vital areas and material access areas within a protected area shall be separated from the physical barriers at the perimeter of the protected area.

- Isolation zones (provided by the safeguards and security system) at least 20 ft wide shall be located on both sides of each barrier on the perimeter of the protected area(s).

- The design shall provide secondary containment around all single-walled fuel storage tanks and petroleum, oil, lubricant, and hazardous material storage sites.

Technical Rationale—Security requirements dictate robust perimeter protection of the protected areas. Also required is the secondary containment of storage sites containing hazardous materials.

4.2.1.2.9 Other Site Impacts

Criteria—Other site impacts for site development shall be due to:

- Impacts on historical and archaeological features
- Impacts on endangered species
- Impacts on the environments.

The site layout should be such that these impacts are minimized. The following points shall be considered:

- The layout design shall not require the disturbance of any known archaeological resource unless the disturbance has been specifically permitted in accordance with the applicable programmatic agreement between the DOE and Advisory Council on Historic Preservation.

- The layout design shall not require the disturbance of any known active desert tortoise (*Gopherus agassizii*) burrow, pallet, den, watering depression, or cover, unless the tortoise is relocated in accordance with the issued biological opinion (Williams 2001 [DIRS 157529]).

Technical Rationale—Conformance with federal requirements for historical and archaeological features is required, as is the protection of endangered species such as the desert tortoise.

4.2.1.2.10 Pollution and Soil Erosion Control

Criteria

- Pollution and soil erosion controls shall be implemented during construction activities to mitigate impacts on air, water, and other environmental resources and ensure compliance with appropriate sections of NAC 445A, Water Controls [DIRS 104040], and NAC 445B [DIRS 104041].

- When riprap is required for erosion control, the riprap shall be a sound, durable stone with an average bulk density not less than 125 lbs/cu ft according to a standard, which will be provided later. The stone shall be graded from 12 in. maximum size to 3 in. minimum, as placed vertically. The largest dimension of any riprap stone shall be no longer than three times the vertical dimension.

Technical Rationale—Construction activities are required to be environmentally responsible and in accordance with the NAC 445A [DIRS 104040] and NAC 445B [DIRS 104041]. Riprap is specified in accordance with good engineering practice.

4.2.1.2.11 Corrosion Potential and Corrosion Control

Criteria

A. General

Typically, metallic underground installations are prone to corrosion. As identified in the soils report, the soil aggressivity to the ferrous metals from alluvium and engineered fill is determined to be lightly corrosive. Types of corrosion control that may be used are protective coatings and cathodic protection.

B. Cathodic Protection Systems

When buried pipelines require cathodic protection, the systems shall be installed at the same time as the piping system.

The interior of steel water tanks shall be protected by the cathodic protection system.

Technical Rationale—BSC (2002 [DIRS 159262]) and BSC (2004 [DIRS 166067]) identify the soil aggressivity to be lightly corrosive to ferrous metals. Required cathodic protection is suggested by good engineering practice.

4.2.1.3 Criteria for Design of Civil Works

4.2.1.3.1 Earthwork

Criteria

A. Clearing, grubbing, stripping, demolition, and disposal

- Clearing—The area within the repository boundary that is required for construction operations shall be cleared of all materials above or at the natural ground surface. Materials to be cleared shall include trees, brush, rubbish, vegetation, and obstructions. However, in certain specified areas, trees and brush may have to be retained and preserved.

- Grubbing—The entire area within the limits of clearing shall be grubbed of all stumps and roots.

- Stripping—All turf and topsoil shall be stripped from the areas, as needed. The approximate depth of stripping shall be 6 in. below the existing ground levels. Turf and topsoil shall be stored for reuse in stockpiles separate from other excavated material.

- Demolition—Redundant buildings and structures shall be demolished and all debris removed. All underground structures and chambers shall be removed and the resulting excavation filled with compacted acceptable material.

- Disposal—Debris from clearing and grubbing operations shall be removed to designated disposal areas. Burning shall not be permitted.

B. Excavation and backfill

- Temporary and permanent earthwork slopes, excavations, and structural fill shall be in accordance with the requirements of BSC (2002 [DIRS 159262]) and BSC (2004 [DIRS 166067]).

- As a minimum, the cut and fill slopes shall meet the requirements of 29 CFR Part 1926 [DIRS 172710].

- Permanent fill slopes shall be no steeper than 2:1 (horizontal to vertical).

- Temporary side slopes for pool excavations estimated to be 50 ft deep shall be no steeper than 1-1/4:1 in alluvium and 1:1 in engineered fill. An 8-ft wide (minimum) bench should be constructed at mid depth of excavation. Alternately, steel sheeting may be used to support the excavation as required.

C. Compaction

All fill, foundation and trench backfill materials, and utility bedding shall be compacted to an in-place density of at least 95 percent of the maximum laboratory dry density as determined by ASTM D 1557-02, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))* [DIRS 164216].

D. Borrow materials

Borrow material may be obtained from a variety of areas, to be designated in the future, and used in accordance with BSC (2002 [DIRS 159262]) and BSC (2004 [DIRS 166067]).

E. Controlled Low-Strength Material

Controlled low-strength material shall be composed, applied, and tested according to applicable ASTM specifications that shall be ordered.

Technical Rationale—BSC (2002 [DIRS 159262] and 2004 [DIRS 166067]) identifies the requirements for earthwork and backfill. The ASTM standards referenced above give the accepted criteria for the materials and testing needed. Compaction required is in accordance with good engineering practice. Safety in construction must conform to federal safety standards.

4.2.1.3.2 Roadways, Parking Areas, Walkways, and Open Areas

Criteria

A. **Road Classification**—YMP roads shall be classified as access roads, service roads and driveways, various surface waste handling vehicles or waste package transporter areas, parking areas, and construction roads.

- The access road runs from U.S. 95 (near Nevada Test Site Gate 510) to the repository.
- Service roads, driveways, and parking areas shall be located in accordance with the site development plan layout.
- Various surface waste handling vehicles or waste package transporter areas shall be those, as required, for movement of those types of equipment.
- Temporary construction roads will be utilized when and where necessary to facilitate onsite construction and through site access traffic.

B. **Design Parameters**—Roads layout and geometry shall conform to Nevada Department of Transportation specifications, which will be identified in a revision. Design parameters not covered in the Nevada Department of Transportation documents shall be based on Design Guides for Highways and Streets, which has been identified and is being procured.

- Access roads shall be designed to be capable of handling legal weight trucks and over weight trucks. The use of heavy haul trucks is on hold at the present time.

- Service roads, driveways, and parking areas shall be capable of handling legal weight trucks and over weight trucks.

- Various surface waste handling vehicles paths shall be capable of handling the movement of fully loaded various surface waste handling vehicles .

- Permanent roads and parking areas shall have a permanent surface such as concrete or asphalt.

- Construction roads shall be a gravel surface or paved surface designed for loading in accordance with a standard that has been identified and is being procured. Economic and service factors shall determine the surface to be used (AASHTO 2002 [DIRS 164304]).

- Minimum road width for fire fighting apparatus shall meet the requirements of Section 4.8.1.5. Roads for firefighting apparatus shall have a maximum grade of 10 percent.

C. **Parking Areas**—Parking areas shall have a minimum slope of one percent in the direction of drainage. Parking areas shall be asphalt paved and sized to accommodate a minimum of (to be provided later) vehicles. Handicapped parking shall be provided at two percent of total available parking.

The handicapped parking and curb ramps for the handicapped shall be marked and dimensioned in accordance with ICC/ANSI A117.1, *Accessible and Usable Buildings and Facilities* [DIRS 158846].

D. **Site Access**—Access to the site shall be via access control points. Within the site, personnel shall walk to their respective work location of the facility.

E. **Walkways**—Walkways shall be provided for pedestrian traffic from designated parking lots to and around all permanent buildings.

F. **Accessibility**—All the buildings and adjoining sites, including parking areas, will require handicap accessibility to the buildings. The access and parking areas shall be designed in accordance with ICC/ANSI A117.1 [DIRS 158846].

G. **Open Areas**—Open areas around building disturbed areas shall be covered with a 3-in. layer of 1-1/4-in. crushed surfacing surface course.

H. **Signs and Markings**—Signs and markings on pavement shall be provided, as necessary, in accordance with *MUTCD 2000 Manual on Uniform Traffic Control Devices* (DOT 2001 [DIRS 164546]).

I. **Power Line Clearance**—The minimum power line clearance shall be as provided in Section 4.3.3, Electrical Design Criteria.

   Standard caution signs shall be placed on both sides of the road where electrical lines cross over roads. Signs shall state the actual clearance from the top of the road to the lowest wire or cable. The sign must be visible at 100 ft away from the overhead lines.

Technical Rationale—Layout of roadways, parking areas, walkways, and open areas are in accordance with BSC (2004 [DIRS 171816]) and code identified, which is being procured. Roadway design is determined by loading conditions in accordance with good engineering practice. Handicapped accessibility complies with ICC/ANSI A117.1 [DIRS 158846]. Minimum clearance of power lines over plant roads will be in accordance with electrical design criteria for clearances.

4.2.1.3.3 Railroad Design

Criteria

The requirements of this section apply to all components of surface rail design except as specifically noted. The boundary between surface and subsurface rail lines is at the portal of the entry tunnel.

A. **General**—The bases for surface railroad facilities design shall be the criteria in *Manual for Railway Engineering* (AREMA 2002 [DIRS 171657]).

B. **Track Layout**—Track layouts shall allow rail movement to be continuous from the interchange yard through the classification yard to the delivery tracks. Each interchange or receiving track shall be designed to accommodate the maximum single delivery. The average number of cars in each classification shall determine the length of classification tracks.

   The minimum radius of the entrance/exit turns at the North Portal entrance shall be 350 ft. The radius for the surface rail where only the emplacement transporters travel shall be 200 ft (Holt 2004 [DIRS 167376]). The minimum radius for the surface rail where conventional engines and railcars travel shall be 400 ft.

   The requirements of this section apply to all components of surface rail design except as specifically noted. The boundary between surface and subsurface rail lines is at the portal of the entry tunnel.

C. **Drainage**—Track-side drainage swales, drainage ditches, intercepting ditches, culverts, lateral drains, pipe drains, and other drainage facilities shall comply with AREMA (2002 [DIRS 171657]).

D. **Structures**—The design strength of railroad structures shall not be less than that required for a Cooper E-80 loading (AREMA 2002 [DIRS 171657]).

E. **Rail**—Rail to be used in new construction or for minor alignment and modifications shall be a new or appropriate grade relayer rail. New rail is preferred for new construction.

F. **Ties**—The use of non-wooden ties shall be allowed, provided the cognizant DOE authority approves the alternative material. Concrete ties shall be used in areas where tie inspection and maintenance entails pavement removal or in locations where track maintenance interferes with other site operations and activities (e.g., railroad and road crossings, paved streets, and paved industrial areas). All wood ties shall be treated with decay-retardant compounds conforming to the requirements of AREMA (2002 [DIRS 171657]). Hardwood ties shall be provided with anti-splitting devices in each end.

G. **Joint Bars**—Joint bars shall be of the size, shape, and punching pattern to fit the rail.

   Compromise Joint Bars—Compromise joint bars shall be used where new or relayer rail joins the lighter weight rail. Each pair of compromise joint bars shall be the proper design and dimensions for the rail on which it is applied.

H. **Tie Plates** (if used)

   New Rail—Tie plates shall be new with or without ribs. Insulating tie plates shall be used in the vicinity of lighted crossings.

   Relayer Rail—Used tie plates shall be in good condition and the proper size; punching can be used with the relayer rail. The size of the used tie plates shall not be smaller than 7-1/2 × 10 in. for an 85-lb relayer rail and 7-1/2 × 11 in. for a 110-lb relayer rail. Tie plates with or without ribs can be used.

I. **Rail Fixtures**—Rail fixtures shall be spaced to comply with AREMA (2002 [DIRS 171657]).

J. **Spikes**—Six-inch by five-eights-inch spikes shall be used for all wooden ties where spikes are used for rail fastening. New track spikes shall be used for new and relayer rail.

K. Not used.

L. **Road–Railway Grade Crossing**—All grade road crossings shall comply with AREMA (2002 [DIRS 171657]) and local highway standards.

M. **Ballast**—The minimum depth of ballast under the ties shall be 8 in. Prepared ballast (stone, gravel, or slag) will be in accordance with AREMA (2002 [DIRS 171657]).

N. **Turnouts**—The surface rail system shall use No. 7 and No. 11 turnouts. Number 7 turnouts shall be used for those parts of the surface rail system where the emplacement transporter and conventional engine only travels. Number 11 turnouts shall be used for those parts of the surface rail system where the conventional engine and railcar travels. Turnouts shall comply with AREMA (2002 [DIRS 171657]).

O. Not used.

P. **Grades**—The maximum grade on access lines shall be determined by the tonnage handled in one train unit. An analysis shall be made to design grades below three percent. Grades shall not exceed 3 percent without approval by the cognizant DOE authority. The design shall be coordinated with the requirements of the serving railroad.

Q. **Clearances**—Clearances for tangent track shall comply with AREMA (2002 [DIRS 171657]). Side clearances shall be measured horizontally from the centerline of tracks. Side clearances on the outside of curves shall be increased 1 in. for each degree of track curvature over that shown for tangent track. Side clearances on the inside of curves shall be increased 1 in. for each degree of track curvature and also 3-1/2 times the amount of super-elevation of the high rail.

R. **Electrical Grounding**—Grounding requirements are presented in Section 4.3.1.4.

Electrical grounding shall comply with NFPA 70-2004, *National Electrical Code* [DIRS 172711].

S. Concrete slab track shall comply with AREMA (2002 [DIRS 171657]).

Technical Rationale—The bases for railroad facilities design are the criteria in AREMA (2002 [DIRS 171657]) and good engineering practice. Railroad structures are designed for Cooper E-80 loading as a very heavy loading.

4.2.1.3.4 Heliport Design

Criteria

A. **General**

- Heliports shall not be located closer to repository facilities than one-half mile per *Facility Location Calculation* (BSC 2004 [DIRS 172230]).

B. **Site Selection**—The following parameter shall be considered to determine the adequacy of the aviation facility:

Site selection for a heliport shall comply with FAA advisory circulars (DOT 1994 [DIRS 164544]).

C. **Airfield Safety Clearances**—Airfield safety clearances shall comply with clearance criteria and the criteria for determining obstructions to air navigation in FAA advisory circulars (DOT 1994 [DIRS 164544]).

D. **Fire and Rescue Facilities**—Fire protection shall comply with the applicable provisions of NFPA 418-2001 [DIRS 170661].

E. **Drainage**—Airport drainage systems shall comply with an FAA advisory circular (DOT 1994 [DIRS 164544]).

F. **Pavements**—Airfield pavements shall be designed in accordance with FAA advisory circular (DOT 1994 [DIRS 164544]).

G. **Pavement Markings**—Marking paved areas at airports and heliports shall comply with an FAA advisory circular (DOT 1994 [DIRS 164544]).

Technical Rationale—Heliport design is in accordance with FAA advisory circulars that pertain to heliport design (DOT 1994 [DIRS 164544]) with the exception of Fire and Rescue Facilities, which will comply with applicable revisions of NFPA 418-2001 [DIRS 170661].

4.2.1.3.5 Sanitary Sewer System

Criteria

A. **System Design**—The system design shall comply with federal and state regulations on water and air pollution and shall be in accordance with American Society of Civil Engineers (ASCE) Manuals and Reports on Engineering Practice No. 60 (ASCE 1982 [DIRS 169217]), No. 77 (Urban Water Resources Research Council 1992 [DIRS 164302]), and ASCE 1991 [DIRS 132149].

   The system shall be designed in accordance with Nevada Division of Environmental Protection, Bureau of Water Pollution Control, and Nevada Administrative Code (NAC) requirements for large onsite sewage systems, which will be identified later. The pressure distribution leach fields shall be designed in accordance with the requirements of the Nevada regulations for onsite sewage systems and Nevada Design Standards for large onsite sewage systems.

   The system design shall be based on EPA 1980, *Design Manual, Onsite Wastewater Treatment and Disposal Systems, EPA-625/1-80-012* [DIRS 169219].

   Quantity of Sanitary Sewage—The rate of sanitary flow shall be calculated on the basis of 15 gal per person per day for the Administration Building and 35 gal per person per day for the remainder of the plant facilities, which will be confirmed later.

   The rate of sanitary flow for the construction phase shall be calculated on the basis of 10 gal per person per day for the total population, which will be confirmed later.

B. **System Layout**—Gravity flow pipelines shall collect and transfer sewage to the septic tanks. Pump stations (dosing tank) shall pump the effluent to the drain fields. A pressurized drain field system shall be used for disposal of the sewage.

The minimum diameters shall be 8 in. for sanitary sewer main lines and 6 in. for laterals.

The minimum grade for various pipes shall be as required for design using the design manuals listed in 4.2.1.3.5A.

Manholes shall be located at all junctions and changes of grade or size of mains. Spacing between manholes on the main lines shall not exceed 400 ft. Cleanouts shall be located at dead ends of laterals and where laterals make a horizontal change in direction. The maximum length of a sewer lateral shall be 100 ft without a cleanout.

Minimum sewer velocities shall be designed in accordance with the manuals, which will be provided later.

Technical Rationale—The sanitary sewer system is designed in accordance with *ESF Sanitary Sewer System Operation and Maintenance Manual* (CRWMS M&O 2000 [DIRS 167332]), Nevada Division of Environmental Protection, NAC requirements, and good engineering practice.

4.2.1.3.6 Storm Drainage System

Criteria—All areas of the YMP shall be designed for storm water runoff, based on the functional requirements of each facility.

- The majority of the site storm water shall be managed in a closed underground drainage system, which exits to a retention pond.
- The storm drainage system shall be designed to handle the flow that is generated by a 100-yr storm event (Section 6.1.1.1) and facilitate fire water runoff.
- The maximum single-source discharge shall be based on average annual precipitation.
- There shall be no process liquid or sanitary sewer contributions to the storm system.
- Building and surface runoff shall be directed toward drainage structures (catch basins) and ditches by sloping the tributary surface area.
- The minimum culverts diameter shall be 18 in.
- Culverts and pipes shall be designed to accommodate the minimum HS20-44 loading in accordance with code that has been identified and is being procured, unless they are located in the areas of heavy haul truck or the surface or waste package transporter. In these cases, appropriate loading from heavy haul truck or surface or waste package transporter shall be considered.

- The drainage ditches shall be trapezoidal in cross section with minimum bottom width of 3 ft and with minimum side slope of 2:1. Roadway ditches may be V-shaped.
- Drainage discharge point shall have a riprap in a fan shape to disperse outfall stormwater flow.
- Drainage ditch slopes shall be based on channel velocity, calculated using the "Manning Formula."
- Drainage ditch slopes shall be set such that the maximum velocities are as follows:
  - In clay and/or silty sand, 2.5 ft/sec
  - In fine gravel, 5 ft/sec
  - In asphalt-lined ditches, 8 ft/sec
  - In concrete and riprap-lined ditches, 18 ft/sec.
- The Manning coefficient of roughness shall be:
  - 0.013 for concrete-lined ditches
  - 0.033 for riprap ditches
  - 0.025 for gravel-lined ditches
  - 0.009 for polyvinyl chloride (PVC) piping.
- Quantity of Storm Flows

  Calculation of the surface runoff peak flow rates shall be by the rational method as follows:

  $Q = CIA$

  Where,

  Q = Peak discharge in cubic feet per second

  C = Coefficient of runoff. The runoff factor, C, shall be:

  0.90 for roofs and impervious pavements
  0.50 for graveled areas
  0.10 for all other open areas.

  The weighted average of coefficient of runoff factor, C, for sub-areas shall be used in the design.

I = Average rainfall intensity in inches per hour for a given frequency and for the duration equal to the time of concentration.

Storm management systems for all areas shall be designed for a 100-year storm as identified in Section 6.1.1.1.2.

A = Drainage area in acres

Technical Rationale—The stormwater drainage system is configured and designed according to good engineering practice using the rational method for surface runoff, which is valid for drainage areas less than 200 acres.

4.2.1.3.7 Water Supply for Surface Facilities

Criteria—The potable water system design shall comply with federal and state regulations on public water systems and water quality. The system shall be designed in accordance with Nevada Division of Health, Bureau of Health Protection Services, and NAC 445A [DIRS 104040] requirements.

Cross-connection control for the potable water system is required. It shall include approved reduced-pressure backflow preventors and shall be designed in accordance with *Recommended Practice for Backflow Prevention and Cross-Connection Control* (AWWA 1990 [DIRS 150790]) and *Potable Water System Operations and Maintenance Manual* (CRWMS M&O 2000 [DIRS 165475]).

A. **Water Demand**—The potable water supply systems shall be designed to deliver a peak flow of 2.5 times the average daily demand, plus any special water demands. Construction requirements and permanent operation requirements will be provided later. The water pressure shall have a minimum residual pressure of 30 psi. Water supply systems shall be designed to maintain a normal operating pressure of 40 to 150 psi in the water main lines and service lines. Working pressure for potable water and fire water is 150 psi for the lines from the water tanks to and on the pad. The minimum test pressure is 200 psi.

B. **Water Pipelines**—In addition to the distribution system requirements in NAC 445A [DIRS 104040], potable water pipeline requirements are as follows:

- The material for water mains shall have a minimum pressure rating of 200 psi.
- Water mains shall be a minimum of 4 in. in diameter. Pipes for water mains shall be PVC or ductile iron, rated for the maximum pressure encountered.
- Service lines shall be a minimum of 1 in. in diameter. Service lines less than 2 in. in diameter shall be connected to the main line by a corporation stop. Service lines 2 in. and larger in diameter shall be connected to the main line by a rigid connection. Service line materials shall be selected on a project-specific requirement basis.

- Underground pressure pipe joints and appurtenances shall have adequate thrust blocks. Above ground pipe joints and appurtenances shall have adequate anchorage systems.

- Underground pipelines shall be installed with at least 36 in. of cover over the piping or at least 12 in. below frost depth, whichever is deeper (NAC 445A [DIRS 104040]). Additional cover shall be provided at roadway crossings in heavy traffic areas and at railroad crossings.

C. **Fire Protection Water Supply**—Requirements for fire protection water supply are as follows:

- The water supply system shall supply water to the fire water storage tanks with sufficient flow to totally refill the tank in eight continuous hours or less.

D. **Disinfection**—Newly constructed potable water mains, mains that have been removed from service for planned repairs or maintenance that exposes them to contamination, mains that have undergone emergency repairs due to physical failure, and mains that under normal operation continue to show the presence of coliform organisms shall be disinfected in accordance with a standard that has been identified and is being procured. Disinfection of the potable water system shall be in accordance with NAC 445A [DIRS 104040] and *Potable Water System Operation and Maintenance Manual* (CRWMS M&O 2000 [DIRS 165475]).

Technical Rationale—The potable water system is designed in accordance with Nevada Division of Health and NAC 445A [DIRS 104040] requirements, and good engineering practice.

4.2.1.3.8 Underground Utilities Pipes

Criteria

- Anchor blocks or joint restraints shall be provided for pressure piping systems at all pipe fittings.

- All underground pipes shall be designed for soil loads and traffic loads. Concrete encasement (reinforced) or pipe casings shall be provided at road crossings or other locations as required by load conditions.

- Sewers shall be lower than water mains and separation requirements between sewers and water mains shall be in accordance with NAC 445A [DIRS 104040].

- Sewer or water main trench widths shall be minimized; however, excavations, trenching, and shoring shall comply with 29 CFR Part 1926 [DIRS 172710], Subpart P. Pipe bedding specified by the pipe manufacturer shall be in place prior to the installation of sewers and water mains.

- General requirements for underground pipelines for fire protection are described in Section 4.8.1.14.

- Piping material for fire protection shall meet the requirements of NFPA 24-2002, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances* [DIRS 160922].

Technical Rationale—Underground utility pipes are designed for pressure loads, soil loads, and traffic loads according to good engineering practice. Separation and configuration of water mains and sewer lines are designed according to NAC 445A [DIRS 104040] requirements and good engineering practice. Access mains for fire lines are configured according to good engineering practice.

4.2.1.3.9 Electrical Duct Bank

Criteria

- All electrical duct banks shall be designed for soil and traffic loads at road and railroad crossings. Traffic loading includes normal HS-20 truck loading and heavy transporter loading where applicable.

- Electrical duct banks shall be located at a depth of a 3-ft minimum cover top of duct bank to finish grade surface. Exceptions to the depth requirement shall be permitted for short portions of 10 percent or less of the entire length of the duct bank run.

- The minimum horizontal clearance between adjacent duct banks shall be 1 ft face to face, except when an other utility is a heat source and then the horizontal clearance will be 3 ft.

Technical Rationale— This criterion is used to facilitate interfaces between the duct bank routing and other underground utilities. This is a common practice in industry for a reliable power distribution system.

4.2.1.3.10 Pipe Rack Utilities

Criteria

- Pipe rack utilities shall be designed based on the structural design criteria.

- Foundation design recommendations for isolated spread footings shall be in accordance with structural design criteria in BSC (2002 [DIRS 159262]) and BSC (2004 [166067]).

Technical Rationale—Pipe rack utilities design is based on structural design criteria and soil loads as specified in BSC (2002 [DIRS 159262]) and BSC (2004 [DIRS 166067]) and according to good engineering practice.

4.2.1.3.11 Fencing

Criteria—The YMP restricted area perimeter shall be fenced to prevent intrusion into the area. Fencing shall be limited to that required for safety, physical security, and activity control.

- All permanent fences shall be galvanized chain fences. Material shall be in accordance withASTM A 392-03, *Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric* [DIRS 174875]..

- Fencing shall be grounded around substations, fuel storage areas, and other hazardous areas.

- The overall fence height, including barbed wire topping, shall be 8 ft nominal.

- Fencing shall be topped with three strands of barbed wire on outriggers. Tension wires at top and bottom shall be used to secure the fence fabric.

- Perimeter fence shall meet the security requirements of the site. Posts, bracing, and other structural members shall be located on the inside of secured perimeters.

- Fencing material shall be 9-gauge, galvanized steel fabric with mesh openings not larger than 2 in. Outriggers shall be angled outward, away from the security area.

- All posts shall be set in concrete. Concrete foundation shall be designed to withstand any strain or shocks ordinarily brought to bear on the fence.

- Gates shall be double swing, unless called out as roll and slide type.

- Electrical grounding shall be provided for all permanent fencing in accordance with NFPA 70-2004 [DIRS 172711].

Technical Rationale—Fencing configuration, material, and construction are required for security and good engineering practice. Grounding is in accordance with NFPA 70-2004 [DIRS 172711].

4.2.1.3.12 Yard Fire Protection

Appropriate design criteria is presented in Section 4.8.1.14.

4.2.1.3.13 Field-Erected Tanks and Tank Foundations

Criteria

- Tanks that contain water for purposes other than fire protection shall meet Nevada Division of Health, Bureau of Health Protection Services, and NAC standards. Water tanks shall meet industrial standards ANSI/AWWA D100-96-1997, *Welded Steel Tanks for Water Storage* [DIRS 160122], and API Std 2000, *Venting Atmospheric and Low-Pressure Storage Tanks, Nonrefrigerated and Refrigerated, with Errata* [DIRS 169966], as applicable. In the case of dual use to include fire protection, NFPA 22-2003, *Standard for Water Tanks for Private Fire Protection* [DIRS 165075], shall be invoked as well.

- Tanks for fire water storage shall meet NFPA 22-2003 [DIRS 165075] requirements.

- Fuel oil, chemical tanks, or other process tanks shall meet industrial standards API Std 650 [DIRS 164288] or API Std 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks* [DIRS 164240], and API Std 2000 [DIRS 169966], as applicable.

- Design tanks for the following loading and ambient conditions as provided in the structural design criteria:

  - Roof load (including snow load)
  - Design wind velocity
  - Seismic load
  - Lowest 1-day mean ambient temperature
  - Allowable soil pressure
  - Ambient temperature range.

- The minimum corrosion allowance for various tank elements shall be:

  - Bottom, 1/8 inch
  - Shell, 1/16 inch
  - Roof plate, 1/16 inch
  - Webs of roof support members, 1/16 inch.

- Provide the roof type required for each tank furnished. Use tubular or pipe section columns for supported cone roofs.

- Provide ladders, fittings, and other appurtenances as required. Terminate ladders 1 ft above finish grade.

- Design ladders, ladder safety cages, platforms, and handrails in accordance with Occupational Safety and Health Administration (OSHA) requirements.

- Provide overflow pipes, vents, nozzles, shell manholes, and roof hatches in accordance with the applicable design code.

- Provide liquid-level indicator, as required.

- Design supports and fasteners for the liquid-level indicator(s) in accordance with manufacturer recommendations.

- Design tank foundations in accordance with accepted design practices.

Technical Rationale—Field erected tanks and tank foundations shall be designed for loadings specified in the structural design criteria. Fire water storage shall meet the requirements of NFPA 22-2003 [DIRS 165075]. Potable water storage tanks shall meet the Nevada Division of Health and NAC requirements. Configuration and appurtenances shall conform to good engineering practice and shall meet the requirements of NFPA 22-2003 [DIRS 165075].

4.2.1.3.14 Postclosure Monuments

To be provided in a revision.

4.2.2 Surface Structural Design Criteria

4.2.2.1 Surface Structural Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Civil/Structural/ Architectural	Structural[b]	ACI 201.2R-01, ACI 301-99, ACI 318-02/318R-02, ACI 349-01, ACI 530-02/ASCE 5-02/TMS 402-02, AISC 1989, AISC 1997, AISC S303-2000, ANSI/AISC 341-02, ANSI/AISC N690-1994, ANSI/ANS-2.8-1992, ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/ANS-6.4-1997, ANSI/ANS-6.4.2-1985, ANSI/ASHRAE/IES 90A-a-1987, ASCE 4-98, ASCE 7-98, ASME NOG-1-2002, ASTM A 108-99, ASTM A 185-01, ASTM A 307-00, ASTM A 325-02, ASTM A 36/A 36M-04, ASTM A 490-02, ASTM A 500-01a, ASTM A 53/A 53M-02, ASTM A 615/A 615M-01b, ASTM A 653/A 653M-01a, ASTM A 706/A 706M-01, ASTM A 992/A 992M-02, ASTM D 5144-00, ASTM F 1554-99, AWS D1.1/D1.1M:2002, CMAA 70-2000, EPRI-NP-6041-SL (EPRI 1991), IEEE Std 739-1995, ICC 2000 [DIRS 159179], MIL-STD-1472F, Notice 1. 2003, NFPA 101®-2003, UCRL-15673 (Bongarra et al. 1985)
		NUREG-0800 (NRC 1987), NUREG-0800 (NRC 1989), Regulatory Guide 1.102, Regulatory Guide 1.117, Regulatory Guide 1.122, Regulatory Guide 1.165, Regulatory Guide 1.59, Regulatory Guide 1.61, Regulatory Guide 1.76, Regulatory Guide 1.91, Regulatory Guide 1.92, Regulatory Guide 3.73, Regulatory Guide 8.8
		10 CFR Part 20, 10 CFR Part 63, 10 CFR Part 73, 29 CFR Part 1910, 29 CFR Part 1926 (Sections 750-761), 36 CFR Part 1191, Appendix A
		DOE O 420.1A, DOE-STD-1020-2002

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the BOP Facility, Transportation Cask Receipt/Return Facility, Dry Transfer Facility, FHF, CHF, Warehouse and Non-Nuclear Receipt, and Remediation Area. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides. Addressing these regulatory guides supports compliance with requirements for the BOP Facility, Transportation Cask Receipt/Return Facility, Dry Transfer Facility, FHF, CHF, Warehouse and Non-Nuclear Receipt Facility, and Remediation Area.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-015/P-020, PRD-015/P-021, and PRD-005.

[4] Addressing these DOE directives supports compliance with the requirements of PRD-018/P-019. Applicable sections of these DOE directives will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.2.2.2 Categorization of Structures, Systems, and Components

Criteria—The surface facilities in the repository handle large quantities of radioactive and hazardous materials. Natural phenomena hazards such as earthquakes, winds, and floods can result in the uncontrolled release of these materials. Consequently, it is necessary to ensure that facility structures shall be designed to withstand the effects of those natural phenomena events that are postulated to occur during the life of the facility.

To ensure that an adequate level of protection is provided for facility workers, co-located workers, and the public from the potential consequences associated with natural phenomena hazards, a graded approach has been employed in the natural phenomena hazard design of the repository. Seismic design basis categories are described in Table 4.2.2-1. The seismic design basis for various structures is summarized in Table 4.2.2-3. Non-SC SSCs are designed to the International Building Code (IBC) (ICC 2000 [DIRS 159179]). The seismic use group, importance factors, and seismic design category per the IBC are provided in Tables 4.2.2-2 and 4.2.2-4. Seismic design inputs are addressed in Section 6.1.3.

Consistent with *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564]), a seismic analysis and design are prepared for ITS SSCs assigned design basis ground motions based on dose consequences of 10 CFR 63.111 [DIRS 173273], due to postulated Category 1 and Category 2 event sequences. For this purpose, three different levels of seismic ground motions are considered in terms of return periods (Table 4.2.2-1):

- Design basis ground motion (DBGM)-1: Mean annual probability of exceedance of 1×10^{-3} (1,000-year return period)

- DBGM-2: Mean annual probability of exceedance of 5×10^{-4} (2,000-year return period)

- Beyond design basis ground motion (BDBGM): Mean annual probability of exceedance of 10^{-4} (10,000-year return period).

Seismic designs of ITS SSCs assigned either DBGM-1 or DBGM-2 shall be prepared to meet the governing Code allowable acceptance criteria. Some ITS SSCs are not required following a seismic initiating event and their seismic design is governed by other repository requirements.

In addition, SSCs ITS designed for DBGM-2 will be evaluated at BDBGM to demonstrate the capacity of the SSCs ITS to perform their intended safety functions at the BDBGM consistent with the methods outlined in BSC 2004 [DIRS 170564].

Technical Rationale—For structures ITS assigned DBGM-1 or DBGM-2, seismic response is in accordance with site-specific information. For conventional structures, seismic response is in accordance with the IBC (ICC 2000 [DIRS 159179]).

Table 4.2.2-1. Seismic Categories for Structures, Systems, and Components Important to Safety

Seismic Design Basis	Earthquake Annual Exceedance Probability	Earthquake Return Period	Remarks
DBGM-1	1×10^{-3}	1,000 years	SSCs are qualified to design codes and standards for 1,000-year return period earthquake loads.
DBGM-2	5×10^{-4}	2,000 years	SSCs are qualified to design codes and standards for 2,000-year return period earthquake loads.
BDBGM	1×10^{-4}	10,000 years	SSCs designed for DBGM-2 are qualified to maintain defined seismic safety function(s) under the 10,000-year return period earthquake. This will be accomplished by ensuring those SSCs remain within acceptable inelastic limits under the 10,000-year return period earthquake.

Table 4.2.2-2. Seismic Use and Importance Factors of Conventional Structures, Systems, and Components Designed to International Building Code

Seismic Use Group	Importance Factor I	SSCs Designed to International Building Code
I	1.0	Conventional SSCs for standard occupancy
II	1.25	SSCs that represent substantial hazard to human life (example: Heavy Equipment Maintenance Facility)
III	1.5	Essential or hazardous (Example: Warehouse and Non-Nuclear Receipt Facility)

Table 4.2.2-3. Seismic Design Basis of Various SSCs

Location	Structures, Systems, and Components	Seismic Basis (DBGM/BDBGM)
Surface	Dry Transfer Facility 1	DBGM-2/BDBGM
	Fuel Handling Facility	DBGM-2/BDBGM
	Canister Handling Facility	DBGM-2/BDBGM
	Dry Transfer Facility 2	DBGM-2/BDBGM
	Transportation Cask Receipt/Return Facility	DBGM-2/BDBGM
	Aging Pads	DBGM-2/BDBGM
	Emergency Power system[a]	DBGM-1
	Central Control Center Facility[a] (Central Control Room)	DBGM-1

NOTE: [a] DBGM-1 is assigned for these facilities based on enhanced safety considerations.

Table 4.2.2-4. Classifications of Conventional Structures, Systems, and Components Designed to International Building Code

Location	Structures, Systems, and Components	Seismic Use Group	Seismic Design Category[a]
Surface	Non-ITS Switchgear Facilities	IBC SUG III	D
	Warehouse and Non-Nuclear Receipt Facility[b]	IBC SUG III	D
	Transportation Cask Buffer Area	IBC SUG III	D
	Heavy Equipment Maintenance Facility/Warehouse	IBC SUG II	C
	Warehouse	IBC SUG III	D
	Utility Building	IBC SUG I	C
	Remaining Balance of Plant Facilities	IBC SUG I	C

NOTE: [a] Seismic Design Categories C and D refer to the IBC (ICC 2000 [DIRS 159179]) definition.
[b] Warehouse and Non-Nuclear Receipt Facility will be evaluated for potential seismic interaction.

Table 4.2.2-5 provides a summary of the structural design codes and standards and their applicability for different seismic category facilities. The application of the particular code or standard is also summarized in the table.

Table 4.2.2-5. Applicability of Design Codes and Standards

Title	Applicability	SSCs ITS	Conventional SSCs
ICC 2000 [DIRS 159179] International Building Code	Seismic Design		X
ASCE 4-98 [DIRS 159618] Seismic Analysis of Safety-Related Nuclear Structures and Commentary	Seismic Analysis	X	
ACI 349-01 [DIRS 158833] Code Requirements for Nuclear Safety-Related Concrete Structures	Design of Concrete Structures	X	
ACI 318-02/318R-02 [DIRS 158832] Building Code Requirements for Structural Concrete	Design of Concrete Structures		X
ANSI/AISC N690-1994 [DIRS 158835] Steel Safety-Related Structures for Design, Fabrication, and Erection	Design of Structural Steel	X	
AISC-1997 [DIRS 107063] Manual of Steel Construction, Allowable Stress Design	Design of Structural Steel		X
ANSI/AISC 341-02-2002 [DIRS 171789] Seismic Provisions for Structural Steel Buildings	Seismic Detailing of Structural Steel (Part III)	X	X
ICC 2000 [DIRS 159179] International Building Code	Minimum Live Loads	X	X
ICC 2000 [DIRS 159179] International Building Code	Wind Load Design Methodology	X	X
ICC 2000 [DIRS 159179] International Building Code	Snow Load Design Methodology	X	X
Code identified, being procured	Design of Steel Deck	X	X

4.2.2.3 Design Loads

SSCs shall be designed for the loads prescribed in this document and as supplemented by any additional criteria for the project.

4.2.2.3.1 Dead Load (D)

Criteria—Dead loads shall be loads that remain permanently in place.

Technical Rationale—Standard structural terminology.

4.2.2.3.2 Live Load (L and L_r)

Criteria—Live loads (L) shall be those loads produced by the use and occupancy of a building or other structure. Live loads on a roof (L_r) are those loads produced (1) during maintenance by workers, equipment, and materials and (2) during the life of the structure by movable objects such as temporary equipment. Also considered to be live loads are the dynamic effects of operating equipment such as cranes and pumps.

Live loads on floors shall be based on ASCE 7-98, *Minimum Design Loads for Buildings and Other Structures* [DIRS 149921], unless otherwise defined or computed for specific facilities.

If no floor loads are defined for a specific building, the following table of uniform loads on different floor areas can be used as guidance for design live loads.

Floor Area	Uniform Load in Pounds per Square Foot
Operating Gallery	
Transfer Operations Area	
Electrical Equipment Area	
Battery Room	
HVAC Equipment Area	
Tools/Parts Storage Area	
Closure Operating Gallery	
Closure Maintenance Area	
Closure Support Area	
Entrance Vestibule	
Exit Vestibule	
Platform and Gratings	
Trench Covers	

Data in this table will be provided later.

Live loads on roofs shall be as stipulated in the IBC (ICC 2000 [DIRS 159179]).

Technical Rationale—Standard structural terminology. Using the IBC (ICC 2000 [DIRS 159179]) is good engineering practice. Uniform loads for specific areas are prevailing design loads for similar industrial facilities.

4.2.2.3.3 Snow Load (S_N)

Criteria—Snow load shall be obtained from Section 6.1.1.1.

Technical Rationale—Using the IBC is good engineering practice.

4.2.2.3.4 Ash Load (A)

Criteria—The roof of the structure shall withstand a design basis volcanic ash fall of 4 in. with a density of 63 lb/ft^3 (Section 4.2.2.3.2, Live Load (L and L_r)).

Technical Rationale—Ash load is based on *MGR External Events Hazards Screening Analysis* (BSC 2004 [DIRS 167266], Section 6.4.53).

4.2.2.3.5 Lateral Earth Pressure (H)

Criteria—Every foundation wall or other wall serving as a retaining structure shall be designed to resist (in addition to the vertical loads acting on it) the incident lateral earth pressures and surcharges. The minimum surcharge load shall be 300 lbs/ft^2 for normal vehicular traffic. Dynamic lateral earth pressures due to design basis earthquake shall be computed for ITS structures from the soil–structure interaction analysis where appropriate. At rest, lateral earth pressure shall be used in the design of structures. Active lateral and passive earth pressures, as appropriate, shall be used in the stability evaluation of structures. Any hydrostatic pressure shall correspond to maximum probable groundwater level. Lateral earth pressure coefficients are summarized in Section 4.2.2.6.7.

Technical Rationale—Surcharge load listed is in conformance with good engineering practice.

4.2.2.3.6 Wind Load (W)

Criteria

- For all structures, the wind loads shall be calculated per the provisions of the IBC (ICC 2000 [DIRS 159179]) using a basic wind speed of 90 mph.

- Refer to the discussion of wind loads in Section 6.1.1.2.

Technical Rationale—Design velocity is the result of discussions in Section 6.1.1.2.

4.2.2.3.7 Tornado Loads (W_t)

Criteria

- For structures ITS, the basic parameters for the tornado loads shall be from *Extreme Wind/Tornado/Tornado Missile Hazard Analysis* (BSC 2004 [DIRS 171471]) and guidance in Regulatory Guide 1.76 [DIRS 106281]:
  - Maximum speed—189 mph
  - Pressure drop—0.81 psi
  - Rate of pressure drop—0.30 psi/sec
  - Tornado generated missiles shall be defined as Spectrum II missiles and are applicable for the YMP site as stated in the current analysis (BSC 2004 [DIRS 171471]). Spectrum II missiles are defined in NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.5.1.4).
- For conventional quality non-SC structures, tornado loads are not applicable.

Technical Rationale—Tornado loads are taken from BSC (2004 [DIRS 171471]) and Regulatory Guide 1.76 [DIRS 106281]. The definition of Spectrum is from NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.5.1.4) and BSC (2004 [DIRS 171471], Table 11).

4.2.2.3.8 Seismic Loads (E)

Criteria

- For structures ITS, the seismic load shall be based on the following:
  - Design ground motions shall be in accordance with the Acceleration Ground Response Spectra provided in Section 6.1.3.
  - Seismic analysis meets the requirements of NUREG-0800 (NRC 1989 [DIRS 165110, 165111, 165112] for Sections 3.7.1, 3.7.2, and 3.7.3, respectively).
  - Seismic analysis methods are in accordance with ASCE 4-98 [DIRS 159618].
  - Damping values shall be in accordance with Regulatory Guide 1.61 [DIRS 149473].
  - Consideration of soil-structure interaction effects.
  - Development of structural/seismic responses (acceleration, moments, and shears).
  - Development of Floor Response Spectra.
- For conventional structures, seismic loads shall be based on seismic use groups listed in the IBC (ICC 2000 [DIRS 159179]).

Technical Rationale—For structures ITS, seismic response is in accordance with Section 6.1.3 with the analysis meeting the requirements of NUREG-0800 (NRC 1989 [DIRS 165110, 165111, 165112] for Sections 3.7.1, 3.7.2, and 3.7.3, respectively). Soil-structure interaction effects shall be considered. For conventional quality structures, seismic response is in accordance with the IBC (ICC 2000 [DIRS 159179]).

4.2.2.3.9 Thermal Loads (T_o, T_a)

Criteria—The design of structures shall include the effects of stresses resulting from variations in temperatures under Category 1 or 2 event sequences. Structures shall also be designed for movements resulting from the maximum seasonal temperature change. The design shall provide for the lags between air temperatures and interior temperatures of massive concrete members or structures. The ambient temperature profile provided in Section 6.1.1.5 shall be used in the determination of the thermal loads.

Operating Temperatures, T_o

Internal temperatures at various locations inside the facility structures during normal operating conditions shall be per the ventilation design criteria.

Accident Temperatures, T_a

Internal temperatures at various locations inside the facility structures during accident conditions shall be identified on a case-by-case basis and coordinated with Environmental Safety and Health (ES&H).

Temperature Effects on Structural Elements

- The temperature effects for structural steel elements shall be in accordance with *Manual of Steel Construction, Allowable Stress Design* (AISC 1997 [DIRS 107063], Part 6).
- The temperature effects for structural concrete elements shall be in accordance with ACI 349-01, *Code Requirements for Nuclear Safety Related Concrete Structures* [DIRS 158833], Appendix A.

Technical Rationale—Stresses resulting from thermal loads, including normal operating conditions and accident scenarios, shall be used in the design of steel and concrete structures in accordance with applicable sections of AISC 1997 [DIRS 107063] and ACI 349-01 [DIRS 158833].

4.2.2.3.10 Creep and Shrinkage Forces

Criteria—Effects of creep and shrinkage shall be included with the dead load, as applicable.

Technical Rationale—Standard engineering practice.

4.2.2.3.11 Fluid Load, F

Criteria—The design of structures shall include the effects of stresses resulting from fluid loads. Fluid loads include loads due to weight and pressure of fluids with well-defined densities and controllable maximum heights. Fluid loads shall include the effects of horizontal sloshing in accordance with Section 3.5.4.3 of ASCE 4-98 [DIRS 159618].

Technical Rationale—Sloshing shall be included in addition to normal fluid loads in accordance with Section 3.5.4.3 of ASCE 4-98 [DIRS 159618].

4.2.2.3.12 Operating Pipe Reactions, R_o

Criteria—Operating pipe reactions shall be included during normal, operating, and shutdown conditions.

Technical Rationale—Standard engineering practice.

4.2.2.3.13 Precipitation Levels

Criteria—Design basis precipitation shall be provided in accordance with Section 6.1.1.1.

Technical Rationale—See Section 6.1.1.1.

4.2.2.3.14 Settlement

Criteria—Buildings and structures shall be designed for the total and differential foundation settlements, resulting from the combined static and dynamic loads. The dynamic settlement is due to dissipation of pore pressure or redistribution of soil stresses from the effects of a design basis earthquake.

Technical Rationale—Standard engineering practice.

4.2.2.3.15 Flood Load (F_a)

Floods are discussed in Section 6.1.2.1.

4.2.2.3.16 Construction Loads on Steel Deck and Framing Supporting Concrete Slabs

Criteria

Steel Deck—Steel deck supporting wet concrete shall be designed for the weight of concrete plus a 50-pounds per square foot (psf) uniformly distributed load.

Structural Steel Framing—Steel framing supporting steel deck shall be designed for the following load case:

- The weight of wet concrete plus a 50-psf uniformly distributed load. In addition, a 5,000 lb concentrated load shall be placed anywhere on the span to maximize moment and shear. The concentrated load is not cumulative and shall not be carried to columns.

A note shall be added to the design drawings issued for construction stating that no rigging shall be permitted from the steel framing during placement of concrete until the concrete has attained its full design strength.

Technical Rationale—Construction loads are values used in good engineering practice.

4.2.2.3.17 Drop Load

Criteria—Postulated drop loads shall be evaluated for local damage (e.g., penetration, perforation, and spalling of a concrete slab) as well as for structural integrity. The acceptability of damage due to the dropped load shall be evaluated by the Integrated Safety Management Process (e.g., penetration may be acceptable, but perforation may not be acceptable due to loss of confinement). The drop load evaluation shall be based on *Design of Structures for Missile Impact* (Linderman et al. 1974 [DIRS 159274]) or other similar applicable reference guides.

Technical Rationale—Linderman (et al. 1974 [DIRS 159274]) provides guidance on drop load evaluations.

4.2.2.4 Structural Design Criteria for Structures that are Important to Safety

The following design criteria are applicable for ITS structures.

4.2.2.4.1 Reinforced Concrete Design

Criteria—Reinforced concrete structures shall be designed for DBGM-1 and DBGM-2 seismic levels in accordance with the strength design method of ACI 349-01 [DIRS 158833] for load combinations and acceptance criteria and are shown in Section 4.2.2.4.4.

The reinforced concrete structures designed for DBGM-2 shall be evaluated for BDBGM seismic levels to ensure the defined seismic safety function(s) are maintained. This will be accomplished by the demonstration of the overall structural performance with limited inelastic behavior. The methodology shown in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564]) shall be utilized for the evaluation of reinforced concrete structures for BDBGM seismic levels.

Technical Rationale—ACI 349-01 [DIRS 158833] is the code for safety-related concrete structures. It will be used for concrete SSCs ITS. The methodology shown in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564]) is applicable for concrete structures evaluated for limited inelastic behavior at BDBGM seismic levels.

4.2.2.4.2 Structural Steel Design

Criteria—Steel structures shall be designed for DBGM-1 and DBGM-2 seismic levels in accordance with ANSI/AISC N690-1994, *American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities* [DIRS 158835], for load combinations and acceptance criteria shown in Section 4.2.2.4.4. Proportioning and detailing for seismic loads shall meet the additional requirements of

ANSI/AISC 341-02-2002, *Seismic Provisions for Structural Steel Buildings* [DIRS 171789], Part III.

The steel structures designed for a DBGM-2 seismic criterion shall be evaluated for a BDBGM seismic level in accordance with ANSI/AISC N690-1994 [DIRS 158835] to assess the overall structural performance for demonstration that building safety is not impaired with limited inelastic behavior. The methodology shown in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564]) shall be utilized for the evaluation of steel structures for BDBGM seismic level.

Technical Rationale—ANSI/AISC N690-1994 [DIRS 158835] is the code for safety-related steel structures. Therefore, it will be used for steel SSCs ITS. The methodology shown in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564]) is applicable for steel structures evaluated for limited inelastic behavior at BDBGM seismic levels.

4.2.2.4.3 Masonry Design

Criteria—Use of masonry shall not be permitted for ITS structures.

Technical Rationale—Construction difficulties make it difficult to get the desired strength in masonry SSCs.

4.2.2.4.4 Load Factors, Load Combinations, and Acceptance Criteria

Criteria

Notations:

A = Ash load

D = Dead load

L = Live load

L_r = Roof live load

S_N = Snow load

E = Earthquake (Seismic) load resulting from DBGM-1, DBGM-2, and BDBGM seismic level definition (corresponding to ACI 349-01 [DIRS 158833], E_{ss} of Section 9.2, and ANSI/AISC N690-1994 [DIRS 158835], E_{ss} of Table Q 1.5.7.1)

H = Lateral earth pressure load

T_a = Thermal loads during accident condition

T_o = Thermal loads during normal operating conditions

F = Fluid load

F' = Buoyant force of design basis flood

R_o = Operating pipe reaction load

S = Allowable stress per allowable stress design (ASD) method

U = Required strength per strength design method

W = Wind load

W_t = Tornado load (This includes effects from tornado wind pressure, tornado-created differential pressure, and tornado-generated missiles.)

Y_m= Missile impact equivalent static load on structure generated by drop load and including appropriate dynamic load factor to account for dynamic nature of the load. (In determining an appropriate static load for Y_m, elasto-plastic behavior may be assumed with appropriate ductility ratios, provided excessive deflection will not result in loss of function of any SSCs ITS.)

In the load combinations provided in this section, the following conditions shall be considered:

A. Where the structural effects of differential settlement, creep, or shrinkage may be significant, they shall be included with the dead load D in all the load combinations. Estimation of these effects shall be based on a realistic assessment of such effects occurring in service.

B. Where any load reduces the effect of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load shall be taken as zero.

C. In the load combinations that include Y_m, appropriate dynamic load factor should be used unless a time-history analysis is performed to justify otherwise.

D. In the load combinations that include W_t or Y_m, the corresponding acceptance limits (U, 1.6S, or 1.7S) should be satisfied first without a tornado missile load of W_t, or without Y_m. When considering these concentrated missile loads, local section strength capabilities may be exceeded provided there would be no loss of function of any SSCs ITS system.

Technical Rationale—Definitions given are standard structural definitions. Conditions listed are to be used with load combinations are good engineering practice.

4.2.2.4.5 Reinforced Concrete Design Load Combinations

Criteria—The following load combinations shall be based on ACI 349-01 [DIRS 158833], Section 9.2, and NUREG-0800 (NRC 1987 [DIRS 103124], Paragraphs II.3.b(ii) and II.5.a of Section 3.8.4):

1. $U = 1.4D+1.7L+1.7(L_r \text{ or } A)+1.4F+1.7H+1.7R_o$
2. $U = 1.4D+1.7L+1.7S_N+1.4F+1.7H+1.7R_o$
3. $U = 1.4D+1.7L+1.7L_r+1.4F+1.7H+1.7R_o+1.7W$
4. $U = 1.4D+1.7L+1.7S_N+1.4F+1.7H+1.7R_o+1.7W$
5. $U = 1.05D+1.3L+1.3(L_r \text{ or } A)+1.05F+1.3H+1.05T_o+1.3R_o$
6. $U = 1.05D+1.3L+1.3S_N+1.05F+1.3H+1.05T_o+1.3R_o$
7. $U = 1.05D+1.3L+1.3L_r+1.05F+1.3H+1.3W+1.05T_o+1.3R_o$
8. $U = 1.05D+1.3L+1.3S_N+1.05F+1.3H+1.3W+1.05T_o+1.3R_o$
9. $U = D+L+L_r+F+H+T_o+R_o+E$
10. $U = D+L+L_r+F+H+T_o+R_o+W_t$
11. $U = D+L+S_N+F+H+T_o+R_o+E$
12. $U = D+L+L_r+F+H+T_a+R_o$
13. $U = D+L+S_N+F+H+T_a+R_o$
14. $U = D+L+L_r+F+H+T_a+R_o+E+Y_m$
15. $U = D+L+L_r+F+H+T_a+R_o+W_t$
16. $U = D+L+S_N+F+H+T_a+R_o+E+Y_m$
17. $U = D+L+S_N+F+H+T_a+R_o+W_t$.

Technical Rationale—The design load combinations listed for reinforced concrete are based on ACI 349-01 [DIRS 158833], Section 9.2, and NUREG-0800 (NRC 1987 [DIRS 103124], Paragraphs II.3.b.(ii) and II.5.a of Section 3.8.4). These are to be used for SSCs ITS.

4.2.2.4.6 Structural Steel Design Load Combinations

Criteria—The following load combinations shall be based on ANSI/AISC N690-1994 [DIRS 158835], Table Q1.5.7.1, and NUREG-0800 (NRC 1987 [DIRS 103124], Paragraphs II.3.c.i(a), II.3.c.ii(a), and II.5.b of Section 3.8.4):

1. $S = D+L+(L_r \text{ or } A)$
2. $S = D+L+S_N$
3. $S = D+L+(L_r \text{ or } A)+R_o+T_o$
4. $S = D+L+S_N+R_o+T_o$
5. $S = D+L+L_r+W$
6. $S = D+L+S_N+W$
7. $S = D+L+L_r+W+R_o+T_o$
8. $S = D+L+S_N+W+R_o+T_o$
9. $1.6\ S = D+L+L_r+R_o+T_o+E$
10. $1.6\ S = D+L+S_N+R_o+T_o+E$
11. $1.6\ S = D+L+L_r+R_o+T_o+W_t$
12. $1.6\ S = D+L+S_N+R_o+T_o+W_t$
13. $1.6\ S = D+L+L_r+T_a+R_o$

14. $1.6\ S = D+L+S_N+T_a+R_o$
15. $1.7\ S = D+L+L_r+T_a+R_o+E+Y_m$
16. $1.7\ S = D+L+S_N+T_a+R_o+E+Y_m$
17. $1.7\ S = D+L+L_r+T_a+R_o+W_t$
18. $1.7\ S = D+L+S_N+T_a+R_o+W_t$.

In load combinations 9 through 18, the stress limit in shear shall not exceed 1.4S in members and bolts.

Technical Rationale—The design load combinations for structural steel are based on ANSI/AISC N690-1994 [DIRS 158835], Table Q1.5.7.1, and NUREG-0800 (NRC 1987 [DIRS 103124], Paragraphs II.3.c.i(a), II.3.c.ii(a), and II.5.b of Section 3.8.4). These are to be used for SSCs ITS.

4.2.2.4.7 Stability Criteria for Structures that are Important to Safety

Criteria—Structures that are ITS shall be evaluated to demonstrate that the buildings are adequately stable against sliding and overturning effects for the following load combinations:

1. $O/S = FS\ (D + H + W)$
2. $O/S = FS\ (D + H + E)$
3. $O/S = FS\ (D + H + W_t)$.

NOTE: O/S = overturning/sliding resistance; FS = factor of safety.

The stability against sliding and overturning will be verified using the static evaluation approach comparing forces and moments versus resistance using a factor of safety of 1.5 for load combination No. 1 and 1.1 for load combinations No. 2 and 3. If static approach is not possible, the following approaches will be used:

- Stability against overturning due to seismic forces shall be evaluated by the energy approach (where the factor of safety against overturning shall be calculated as the ratio of potential energy required to cause overturning about one edge of the structure to the maximum kinetic energy in the structure due to the earthquake).

- The effect of building sliding due to seismic forces shall be evaluated by the use of energy or time-history approach to demonstrate that any potential building displacements are inconsequential to the structural integrity of the building. However, the commodities (piping and electrical cable) attached to the building shall be designed so that the commodities shall have an adequate factor of safety to withstand the results from the building displacements.

Technical Rationale—The listed load combinations for evaluating sliding and overturning are from NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.8.5). Resistance against overturning shall be evaluated by energy approach, and the effect of building sliding shall be evaluated by the use of energy or time history approaches.

4.2.2.4.8 Deflection Limits

Criteria

- Reinforced concrete members

  Deflections in reinforced concrete members shall be computed based on cracked section properties. Control of deflections in reinforced concrete members shall be in accordance with ACI 349-01 [DIRS 158833], Section 9.5.

- Structural steel members

  The deflection requirements shall be in accordance with ANSI/AISC N690-1994 [DIRS 158835], Section Q1.13 and Comments CQ1.13.

- Crane runway support beams and monorails

  The following requirements are used:

  - Maximum vertical deflection (loads without impact) = Lr/600 (CMAA 70-2000 [DIRS 153997]).
  - Maximum lateral deflection = Lr/400 (CMAA 70-2000 [DIRS 153997]).
  - Steel deck—The live load deflection shall not exceed (to be provided later).

Technical Rationale—Control of deflections in reinforced concrete members is in accordance with ACI 349-01 [DIRS 158833], while the deflection requirements for structural steel members are in accordance with ANSI/AISC N690-1994 [DIRS 158835]. Crane runway deflection is in accordance with CMAA 70-2000 [DIRS 153997].

4.2.2.4.9 Anchorage

Criteria—Anchorage Rods and Concrete Expansion Anchors

Anchorage design for SSCs ITS shall meet the following:

- Design of anchor rods shall be in accordance with ACI 349-01 [DIRS 158833], Appendix B, Steel Embedments.

- Allowable design capacities of concrete expansion anchors shall be based on manufacturer recommendations and shall include a minimum factor of safety of 4 of the mean ultimate capacity. Manufacturer test data shall be current and shall be approved and published by the International Conference of Building Officials.

Technical Rationale—Design of anchor rods for SSCs ITS shall be in accordance with ACI 349-01 [DIRS 158833]. Expansion anchors for SSCs ITS shall have test data approved and published by the International Conference of Building officials.

4.2.2.4.10 Story Drift

Criteria—Story drift for ITS structures shall be as follows:

- Story drift shall be calculated from a dynamic, elastic analysis.
- Calculated drift shall include translational as well as torsional deflections.
- Calculated story drift shall not exceed 0.01 times the story height for structures with a contribution to distortion from shear and flexure. For structures in which shear distortion is the primary contributor to drift, the calculated story drift shall not exceed 0.004 times the story height.

Technical Rationale—Story drift limitations for ITS structures conform to good engineering practice.

4.2.2.4.11 Foundation Design

Criteria—The foundation design for ITS structures shall meet the requirements of NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.8.5). For ITS structures, the foundation stability criterion is addressed in Section 4.2.2.4.7.

Technical Rationale—The foundation design for ITS structures shall meet the requirements of NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.8.5).

4.2.2.5 Structural Design Criteria for Conventional Structures

The following design criteria for the conventional structures are applicable for seismic use groups listed in the IBC (ICC 2000 [DIRS 159179]).

4.2.2.5.1 Reinforced Concrete Design

Criteria—Reinforced concrete structures shall be designed in accordance with ACI 318-02/318R-02 [DIRS 158832].

Technical Rationale—ACI 318-02/318R-02 [DIRS 158832] is the standard engineering code for reinforced concrete conventional structures.

4.2.2.5.2 Structural Steel Design

Criteria—Steel structures shall be designed in accordance with:

- ASD method using AISC 1997 [DIRS 107063] and *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, June 1, 1989, with Commentary* (AISC 1989 [DIRS 159157])
- Detailing for seismic loads shall meet the additional requirements of Table 4.2.2-4.

Technical Rationale—The ASD method (AISC 1989 [DIRS 159157]) is widely accepted for structural steel design and detailing requirements as listed in the IBC (ICC 2000 [DIRS 159179]).

4.2.2.5.3 Masonry Design

Criteria—Masonry shall be designed in accordance with the IBC (ICC 2000 [DIRS 159179]).

Technical Rationale—Masonry is acceptable for conventional structures. Using the IBC is good engineering practice.

4.2.2.5.4 Load Factors, Load Combinations, and Acceptance Criteria

Criteria

Notations:

D = Dead Load
L = Live Load
L_r = Roof Live Load
S_N = Snow Load
E = Earthquake (Seismic) Load
H = Lateral Earth Pressure Load
T_a = Thermal Force
F = Fluid Load
S = Allowable Stress per ASD Method
U = Required Strength per Strength Design Method
W = Wind Load.

In the load combinations provided in Sections 4.2.2.5.4.1, 4.2.2.5.4.2, and 4.2.2.5.4.3, the following load conditions shall be considered:

A. Where the structural effects of differential settlement, creep, or shrinkage may be significant, they shall be included with the dead load D in all the load combinations. Estimation of these effects shall be based on a realistic assessment of such effects occurring in service.

B. Where any load reduces the effect of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load shall be taken as zero.

Technical Rationale—Definitions given are standard structural definitions. Conditions listed are to be used with load combinations, which are good engineering practice.

4.2.2.5.4.1 Reinforced Concrete Design Load Combinations

Criteria—The following load combinations shall be based on ACI 318-02/318R-02 [DIRS 158832], Section 9.2, and the IBC (ICC 2000 [DIRS 159179], Section 1605.2.1):

1. $U = 1.4(D+F)$
2. $U = 1.2(D+F+T)+1.6(L+H)+0.5(L_r \text{ or } S_N)$
3. $U = 1.2D+1.6(L_r \text{ or } S_N)+(1.0L \text{ or } 0.8W)$
4. $U = 1.2D+1.6W+1.0L+0.5(L_r \text{ or } S_N)$
5. $U = 1.2D+1.0E+1.0L+0.2S_N$
6. $U = 0.9D+1.6W+1.6H$
7. $U = 0.9D+1.0E+1.6H$

NOTES: 1. The load factor on L in load combinations 3, 4, and 5 above shall be permitted to be reduced to 0.5 except for garages, areas occupied as places of public assembly, and all areas where L is greater than 100 lbs/ft^2.

2. The load factor for H shall be zero in load combinations 6 and 7 if structural actions due to H counteract that due to W or E. Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

Technical Rationale—The design load combinations listed for reinforced concrete are based on ACI 318-02/318R-02 [DIRS 158832] and the IBC (ICC 2000 [DIRS 159179], Section 1605.2.1). These are to be used for conventional SSCs.

4.2.2.5.4.2 Structural Steel Design Load Combinations

Criteria—The following load combinations shall be based on the IBC (ICC 2000 [DIRS 159179], Section 1605.3.2):

1. $S = D+L+L_r$
2. $S = D+L+S_N$
3. $S = 0.75(D+L+1.3W)$
4. $S = 0.75(D+L+S_N/2+1.3W)$
5. $S = 0.75(D+L+S_N+0.65W)$
6. $S = 0.75(D+L+S_N+E/1.4)$
7. $S = 0.75(0.9D+E/1.4)$.

Exception: Crane hook loads need not be combined with roof live load or with more than three-fourths of the snow load or one-half of the wind load.

NOTE: For anchorages against overturning, uplift, and sliding, where portions of resistance are provided by dead load, only 2/3 of the minimum dead load likely to be in place during the design wind event shall be used.

Technical Rationale—The design load combinations listed for structural steel are based on the IBC (ICC 2000 [DIRS 159179], Section 1605.3.2). These are to be used for conventional SSCs.

4.2.2.5.4.3 Masonry Design Load Combinations

Criteria—The load combinations and acceptance criteria for masonry design shall be in accordance with the IBC (ICC 2000 [DIRS 159179], Chapter 21).

Technical Rationale—This is good engineering practice.

4.2.2.5.5 Stability Criteria for Conventional Structures

Criteria—Conventional structures shall be evaluated to demonstrate that the buildings are adequately stable against sliding and overturning effects for the following load combinations:

Load Combination

1. O/S = (FS)(D + H + W)
2. O/S = (FS)(D + H + E/1.4)

O/S = overturning or sliding resistance

FS = factor of safety (FS = 1.5)

Technical Rationale—The load combinations listed conform to good engineering practice.

4.2.2.5.6 Deflection Limits

Criteria

- Reinforced Concrete Members

  Control of deflections in reinforced concrete members shall be in accordance with ACI 318-02/318R-02 [DIRS 158832], Section 9.5.

- Structural Steel Members

  The deflection requirements shall be in accordance with AISC (1997 [DIRS 107063], Section L3 and commentary Section L3).

- Crane Runway Support Beams and Monorails

  The allowable deflection of runway support beams and monorails shall be in accordance with the requirements of Section 4.2.2.4.8 of this criterion.

- Steel Deck

  The allowable live load deflection of steel deck shall be in accordance with the requirements of Section 4.2.2.4.8 of this criterion.

Technical Rationale—Deflection limits for reinforced concrete members are in accordance with ACI 318-02/318R-02 [DIRS 158832], Section 9.5. For structural steel members, the deflection limits are in accordance with AISC (1997 [DIRS 107063], Section L3 and commentary Section L3). For crane runways and steel deck, the deflection limits are the same for conventional SSCs as for SSCs ITS.

4.2.2.5.7 Anchorage

Criteria—Anchorage design of conventional SSCs shall meet the following:

- Design of anchor rods shall be in accordance with *Strength Design of Anchorage to Concrete* (Cook 1999 [DIRS 159359]).
- Allowable design capacities of concrete expansion anchors shall be based on manufacturer recommendations. Manufacturer test data shall be current and shall be approved by the International Conference of Building Officials.

Anchorage of Conventional Concrete and Masonry Walls:

- The anchorage of the walls shall be capable of resisting the largest of the horizontal forces specified in the IBC (ICC 2000 [DIRS 159179], Sections 1604.8.2 and 1620.2.0). Walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 ft. Anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall.

Technical Rationale—Design of anchor rods is in accordance with Cook (1999 [DIRS 159359]), which conforms to good engineering practice. Anchorage of walls is based on the largest of forces specified in the IBC (ICC 2000 [DIRS 159179], Sections 1604.8.2 and 1620.2.0).

4.2.2.5.8 Story Drift

Criteria—Story drift for conventional structures shall be based on the provisions of the IBC (ICC 2000 [DIRS 159179], Section 1617.3).

Technical Rationale—Story drift for conventional structures conform to the IBC (ICC 2000 [DIRS 159179], Section 1617.3), which is good engineering practice.

4.2.2.5.9 Foundation Design

Criteria—Foundation design for the conventional structures shall be in accordance with the IBC (ICC 2000 [DIRS 159179], Chapter 18).

Technical Rationale—Foundation design for conventional SSCs shall be in accordance with the IBC (ICC 2000 [DIRS 159179], Chapter 18).

4.2.2.6 Materials

4.2.2.6.1 Structural Steel

Criteria—Structural steel material designation shall be those identified in Table 4.2.2-6.

Technical Rationale—Structural steel material as identified in Table 4.2.2-6 conforms to what is considered as good engineering practice.

Table 4.2.2-6. Structural Steel Material Designation

Section(s)	ASTM Standard	F_y (ksi)	F_u (ksi)
W-shapes	A992/A 992M-02	50	65
M-shapes	A36/A 36M-04	36	58
S-shapes	A36/A 36M-04	36	58
HP-shapes	A36/A 36M-04	36	58
Channels	A36/A 36M-04	36	58
Angles	A36/A 36M-04	36	58
Structural plate	A36/A 36M-04	36	58
Structural tees	(per source of split section)		
Steel pipe	A53/A 53M-02	35	60
Round hollow structural shape	A500-01a Grade B	42	58
Square and rectangular hollow structural shape	A500-01a Grade B	46	58
Anchor rods	F1554-99	36/55	58/75
Welded studs	A108-99	*	*
Steel deck (galvanized)	A653/A 653M-01a	33	*
Stainless steel plates	*	*	*

* To be added later

4.2.2.6.2 Concrete and Reinforcing

Criteria

- Concrete—The 28-day compressive strength, f'_c for the concrete shall be the choice of the design engineer for a given application. The design f'_c for the given application shall be indicated on the structural drawings. The following f'_c values are recommended for design of surface facilities.
  - Structures ITS, f'c = 4,000 psi or 5,000 psi
  - Conventional Structures, f'c = 3,000 psi or 4,000 psi.

- Reinforcing Steel shall comply with ASTM A 706/A 706M-01, *Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement* [DIRS 159360]. ASTM A 615/A 615M-01b, *Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement* [DIRS 158033], Grade 60 reinforcement shall be permitted if:
  - The actual yield strength based on mill tests does not exceed the specified yield strength by more than 18,000 psi (retests shall not exceed this value by more than an additional 3,000 psi).
  - The ratio of the actual ultimate tensile strength to the actual tensile yield strength is not less than 1.25.
- Welded Wire Fabric: ASTM A 185-01, *Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete* [DIRS 157994].

Technical Rationale—Compressive strength specified is reasonable for the area of use. Either ASTM A 706/A 706M-01 [DIRS 159360] or ASTM A 615/A 615M-01b [DIRS 158033] may be used for reinforcing steel providing ASTM A 615/A 615M-01b [DIRS 158033] meets the requirements stated for ductility.

4.2.2.6.3 Masonry

Criteria—All masonry shall be composed of grouted hollow concrete units and shall have a minimum compressive strength, f'_m, of 1,500 psi. The minimum compressive strength shall be reduced by 50 percent, unless special inspection requirements are specified for the construction of masonry elements.

Technical Rationale—Requirements given conform to good engineering practice.

4.2.2.6.4 Structural Bolting Materials

Criteria—Structural bolting shall be limited to the following:

- ASTM A 325-02, *Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength* [DIRS 158936], with standard that has been identified and is being procured.
- ASTM A 490-02, *Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength* [DIRS 158937], with standard that has been identified and is being procured.

Structural connections shall be bearing type connections except where slip critical connections are essential (such as load reversal). Sizes for structural bolting material should be limited to 7/8-inch diameter for all ASTM A 325-02 [DIRS 158936] bolts or 1-1/8-in. diameter for ASTM A 490-02 [DIRS 158937] bolts.

Bolting of members that are not considered to be part of the main building structure (i.e., stair or platform connections) may utilize ASTM A 307-00, *Standard Specification for Carbon Steel*

Bolts and Studs, 60,000 PSI Tensile Strength [DIRS 154217], bolts. The maximum size of ASTM A307-00 [DIRS 154217] bolts shall be 3/4-inch diameter.

Technical Rationale—Either ASTM A 325-02 [DIRS 158936] or ASTM A 490-02 [DIRS 158937] bolts may be used for structural steel connections depending on the size of the forces being resisted. Limiting the size for each negates the possibility of using the wrong strength bolt in any connection. ASTM A 307-00 [DIRS 154217] bolts are sufficient for the application given.

4.2.2.6.5 Welding Material

Criteria—Welding electrodes shall be E70XX (AWS D1.1/D1.1M:2002, *Structural Welding Code—Steel* [DIRS 157203]).

Technical Rationale—The welding electrodes specified are commonly used in steel construction.

4.2.2.6.6 Structural Analysis/Design Material Properties

Criteria—The following values shall be used in an analysis of steel and concrete structures:

Steel:	Modulus of Elasticity	$E_s = 29 \times 10^6$ psi
	Poisson's Ratio	$\nu = 0.3$
Concrete:	Modulus of Elasticity	$E_c = 3.32 \times 10^6$ psi (for $f'_c = 3{,}000$ psi)
		$E_c = 3.83 \times 10^6$ psi (for $f'_c = 4{,}000$ psi)
		$E_c = 4.29 \times 10^6$ psi (for $f'_c = 5{,}000$ psi)
	Poisson's Ratio	$\nu = 0.17$

NOTE: The above value for E, the modulus of elasticity for concrete, is determined in accordance with ACI 318-02/318R-02 [DIRS 158832], Section 8.5, or ACI 349-01 [DIRS 158833], Section 8.5, where:

$$E_c = w_c^{\,1.5}\, 33\, (f'_c)^{1/2}$$

where w_c is the unit weight for concrete in lb/ft^3.

For design calculations, the following unit weight (material density) values shall be used:

Concrete:	150 pcf
Steel:	490 pcf

Technical Rationale—The values given for steel and concrete are commonly used in good engineering practice.

4.2.2.6.7 Geotechnical Design Parameters and Foundation Design Recommendations

Criteria—Geotechnical Design Parameters

The geotechnical design parameters shall be those listed in Tables 4.2.2-7 and 4.2.2-8.

Table 4.2.2-7. Static and Dynamic Soil Parameters

Material	Case	Elastic Modulus E (ksi)	Coefficient of Subgrade Reaction, Ver. (kcf)
Alluvium	Static	30 - 75	155 - 520
	Dynamic	100 - 500	310 - 1,040
Engineered Fill	Static	14 - 28	75 - 250
	Dynamic	30 - 170	150 - 500

Source: BSC 2004 [DIRS 166067], Table 11-1.

Table 4.2.2-8. Friction and Lateral Soil Pressure Coefficients

Material	Moist Density (pcf)	Friction Angle (degrees)	Friction Coefficient (δ)[a]	Soil Pressure		
				Active Pressure Ka	At-Rest Pressure Ko	Passive Pressure Kp
Alluvium	114 - 117	39	0.81	0.23	0.37	4.4
Engineered Fill	127	42	0.90	0.20	0.33	5.0

Source: BSC 2004 [DIRS 166067], Table 11-1.

NOTE: [a] Friction Coefficient = tan φ. These values do not include a factor of safety.

Technical Rationale—The above design soil parameters are taken from the project soils report (BSC 2004 [DIRS 166067]).

Foundation Design Recommendations

1. Foundation pressures for square and continuous footings are presented in *Supplemental Soils Report* (BSC 2004 [DIRS 166067], Figures 11-2 and 11-3).

2. Estimated settlements of square and strip footings are presented in *Supplemental Soils Report* (BSC 2004 [DIRS 166067], Figures 11-4 through 11-6).

3. Estimated settlements for a mat foundation are presented in *Supplemental Soils Report* (BSC 2004 [DIRS 166067], Table 11-2).

4. Recommended material properties are summarized in *Supplemental Soils Report* (BSC 2004 [DIRS 166067], Table 11-1).

5. Recommended surface facilities foundation design parameters are summarized in *Supplemental Soils Report* (BSC 2004 [DIRS 166067], Table 11-2).

4.2.3 Architectural Design Criteria

4.2.3.1 Architectural Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Civil/Structural/ Architectural	Architectural[b]	ANSI Z358.1-2004, ANSI/ASHRAE/IESNA Std 90.1-2004, ASTM E 108-04, ASTM E 84-98, DOT 1994, FM 4471 1995, ICC 2000 [DIRS 159179], ICC 2000 [DIRS 159180], ICC/ANSI A117.1-1998, NFPA 10-2002, NFPA 101®-2003, NFPA 221-2000, NFPA 256-2003, NFPA 801-2003, UL 2003 [DIRS 167310], UL 790 2004 [DIRS 173419]
		NUREG-1804, Regulatory Guide 8.8
		28 CFR Part 36, 29 CFR Part 1910
		DOE O 420.1A

Technical Rationale:

1 These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21 (c)(2) [DIRS 173273]), PRD-022, and the Transportation Cask Receipt/Return Facility, Warehouse and Non-Nuclear Receipt Facility, Dry Transfer Facilities 1 and 2, Remediation Area, CHF, Fuel Handling Facility (FHF), and BOP Facility. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

2 This regulatory guide has been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide.

3 Addressing CFRs supports compliance with requirements for the Transportation Cask Receipt/Return Facility, Warehouse and Non-Nuclear Receipt Facility, Dry Transfer Facility, Remediation Area, CHF, FHF, and BOP Facility, PRD-015/P-015, PRD-015/P-020, PRD-015/P-021, and PRD-005.

4 Addressing the DOE directive supports compliance with the requirements of PRD-018/P-019. Applicable sections of this DOE directive will be determined during the design process and in the development of design products.

a Safety classifications are only provided for SSCs.

b Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.2.3.2 Project Facilities

The project facilities consist of two general types depending on their location: those at the North Portal and those in the BOP. Generally, the main facilities at the North Portal include process type facilities; whereas, the BOP provides non-process administration, infrastructure, and support facilities.

4.2.3.2.1 Main Facilities in the North Portal

Criteria—The main North Portal facilitiesshall include the following:

A. **Dry Transfer Facility 1 (DTF 1), Area 110**—The main structure for this facility is constructed of a reinforced concrete foundation mat, floor slabs, a roof slab, and walls. The floor and roof slabs are supported from concrete walls and the steel floor support system. The vestibules and superstructure above the roof are constructed of steel structures.

B. **Dry Transfer Facility 2 (DTF 2), Area 120**—This structure has the same characteristics and function as DTF 1.

C. **Canister Handling Facility (CHF), Area 190**—The main structure for this facility is constructed of a reinforced concrete foundation mat, floor slabs, a roof slab, and walls. The floor and roof slabs are supported from concrete walls and the steel floor support system. The vestibules and superstructure above the roof are constructed of steel structures.

D. **Transportation Cask Receipt/Return Facility, Area 14A**—This structure has a reinforced concrete mat foundation and ground floor slab with steel framing and metal siding and roofing.

E. **Warehouse and Non-Nuclear Receipt Facility, Area 230**—This facility is a non-nuclear facility constructed of steel structure on reinforced concrete foundation mat.

F. **FHF, Area 210**—The main structure for this facility is constructed of a reinforced concrete foundation mat, floor slabs, a roof slab, and walls. The floor and roof slabs are supported from concrete walls and the steel floor support system. The vestibules and superstructure above the roof are constructed of steel structures.

G. **Surface Aging Facility, Area 170**—This information to be supplied later.

Technical Rationale—The buildings in this area contain heavy industrial processes that require shielding and confinement. Furthermore, they have large seismic loads due to tall heights and large floor areas. These require the use of massive, non-combustible structures and systems. The selection of materials and systems in this area comply with operational demands as well as applicable codes and standards.

4.2.3.2.2 BOP Facilities

Criteria—The BOP buildings shall have non-combustible building systems of construction Types II or I as defined by the IBC and other applicable codes, ordinances, and regulations. The buildings shall have an appearance consistent with the character theme of this site. Generally, all buildings shall have at least R-30 insulation for roofs and R-19 insulation for walls, except for special cases such as thoses with evaporative cooling.

Technical Rationale—The BOP buildings house ordinary office and light industrial usage therefore to comply with applicable codes and standards they require only conventional commercial-grade structures and systems, such as found in business offices and warehouses.

As defined in the *Project Functional and Operational Requirements* (hereinafter referred to as the F&OR) (Curry 2004 [DIRS 170557]), the BOP facilities shall include the following seven types: (1) Administration, (2) BOP Security, (3) Utility, (4) Emergency Response, (4) Offsite, (5) Materials and Consumables, (6) Maintenance and Repair, and (7) Control.

A. Administration Facility, Area 620

Criteria—This facility contains a food service facility, training auditorium, computer operation center, and emergency operations center. The building consists of a multi-story steel frame structure with tilt-up concrete panels or precast concrete panels for the exterior walls, with steel structure roof of trusses and metal deck and single ply membrane roofing.

Technical Rationale—The selected configuration, materials and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.

B. BOP Security Facilities

The BOP security facilities defined in the F&OR consist of a Perimeter Security Station, Central Security Station, Cask Receipt Security, and North and South Administration Security.

1. *Criteria*—The North Perimeter Security Station, Area 30C, the building consists of modular construction with a floor area of approximately 150 sq ft.

2. *Criteria*—The Central Security Station, Area 30A, controls access to the GROA for primary plant employees and nonnuclear equipment. Other security stations will control supplemental access under special conditions. The Central Security Station construction consists of tilt-up or cast in place concrete exterior walls, a structure of steel trusses and steel beams with metal deck roof, and single ply roofing.

3. *Criteria*—Cask Receipt Security Station, Area 30B, receives various casks from sources off site. This information shall be supplied later.

4. *Criteria*—The Administration Security Stations (South and North), Areas 65A and B, control access to the administrative support area for all personnel and non-nuclear equipment. These buildings consist of small, possibly premanufactured, kiosk-style guard stations.

C. Utilities

Criteria—These facilities shall provide common infrastructure for the entire project such as electrical power and fire water.

1. Utilities Facility, Area 25A—The Utilities Facility provides hot and chilled water for the heating, ventilation and air-conditioning (HVAC) plant heating and cooling system; compressed air; battery power; deionized water and analytical lab; a local control room; and minimal offices and locker spaces. Its construction consists of tilt-up or cast in place exterior walls, a structure of steel trusses and steel beams with metal deck roof, and single ply roofing.

2. Cooling Tower, Area 25B—This facility supports the requirements of the Utilities. This facility occupies an open fenced area with small equipment enclosures where required.

3. Evaporation Pond, Area 25C—This facility holds surface runoff in an open basin.

4. Service Gases Storage Area, Area 25D—This facility provides secure storage for bottled and distributed gases. This facility occupies an open fenced area with equipment enclosures as required

5. 4.16 kV Switchgear Facility, Area 26A—This facility forms part of the electrical power supply and distribution system for the site. This facility occupies an open fenced area with small equipment enclosures where required.

6. Standby Generator Facility, Area 26B—This facility provides standby power and has tilt-up or cast-in-place concrete exterior walls, steel column, truss and beam roof structure, with metal deck roof and single ply roofing.

7. Emergency Generator Facility, Area 26C—This facility houses the emergency diesel generators and has tilt-up or cast-in-place concrete exterior walls, steel column, truss and beam roof structure, with metal deck roof and single ply roofing.

8. Switchyard (230kV & 138 kV), Area 27A—This facility forms part of the electrical power supply and distribution system for the site. This facility occupies an open fenced area with small equipment enclosures where required.

9. 12.47 kV Switchgear Facility, Area 27B—This facility forms part of the electrical power supply and distribution system for the site. This facility occupies an open fenced area with small equipment enclosures where required.

10. Fire Protection, Area 280—The Fire Water Facilities (Central, South, East, West and North) provide water storage and pumping to supply water based fire sprinkler systems, standpipes, and fire hydrants to the various facilities associated with this site.

Technical Rationale—The selected configuration, materials and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.

D. Emergency Response Facilities

Criteria—The emergency response facilities shall house personnel and equipment needed in case of medical or other emergency. In accordance with the F&OR, these facilities shall include (1) Fire/Rescue/Medical facilities and (2) a helicopter pad.

1. Fire, Rescue, and Medical Facilities (Operations), Area 63A—These facilities provide space for fire fighting and rescue equipment with associated dormitories, lockers and central fire alarm monitoring. Space for a fire extinguisher maintenance shop is also provided. The Fire/Medical Facility provides space for testing, examination, and a trauma space with a radiological decontamination holding area. The Rescue/Medical Facility functions in conjunction with the helicopter pad.

2. Fire, Rescue, and Medical Facilities (Construction), Area 63B—This facility provides space for fire fighting and rescue equipment with associated dormitories, lockers, fire extinguisher maintenance, central fire alarm monitoring, and space for testing, examination, and trauma care with a radiological decontamination holding area. This facility functions with the helicopter pad.

3. Helicopter Pad (Operations), Area 66A—The helicopter pad provides space for emergency helicopter operations and complies with the FAA Advisory Circular 150/5390-2A, *Heliport Design* (DOT 1994 [DIRS 164544]). The landing and approach areas encompass a 5,000-ft radius from the helicopter touch down zone.

4. Helicopter Pad (Construction), Area 66B—The helicopter pad provides space for emergency helicopter operations and complies with the FAA Advisory Circular 150/5390-2A (DOT 1994 [DIRS 164544]). The landing and approach areas encompass a 5,000-ft radius from the helicopter touch down zone.

Technical Rationale—The selected configuration, materials, and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.

E. Offsite Facilities

Criteria—In accordance with the F&OR, the offsite facilities shall include the following four facilities: (1) a visitor center, (2) training facility, (3) gates and (4) emergency management facility.

1. Visitor Center, Area 610—Provides space for 100 concurrent visitors. Information supplied later.

2. Offsite Training Facility, Area 980—Information supplied later.

3. Gate 510 Facilities, Area 730—(Under development).

4. Emergency Management Center, Area 970—(Under development).

***Technical Rationale*—**The selected configuration, materials, and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.

F. Materials and Consumables Facilities

Criteria—In accordance with the F&OR these facilities shall include a warehouse, fuel depot, waste handling area and a non-radiological/non-hazardous material area.

1. Warehouse/Central Receiving, Area 68A—The central warehouse receives non-nuclear materials and consumables for the site including maintenance materials and parts. Its construction is of tilt-up or cast in place exterior walls, structure of steel trusses and steel beams with metal deck roof and single ply roofing.

2. Fuel Depot, Area 700—The fuel depot provides a canopy space for vehicle refueling. Bulk storage of No. 2 diesel fuel oil and diesel fuel will be provided in quantities to be determined later.

3. Low-Level Waste Handling, Area 160—This facility provides an area for collecting, staging, and handling of LLW generated within the various facilities of the main North Portal area. The final configuration comes from the anticipated volume of wastes generated for legal disposition off site.

4. Hazardous Materials Collection—This area sits adjacent to the Vehicle Maintenance and Motor Pool Facility and holds anticipated quantities of oil, batteries, and other hazardous materials identified as recyclable materials for the collection, staging, and legal disposition off site. Process water that collects in the tunnels during construction is pumped out of the subsurface facility. The location for the treatment of water will be developed later.

5. Nonradiological/Non-Hazardous Materials Areas—This area stores collected materials for legal disposition off site. Design derives from the probable quantities of materials and the final configuration depends on the anticipated volume of wastes generated for legal disposition off site.

***Technical Rationale*—**The selected configuration, materials, and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.

G. Maintenance and Repair Facilities

Criteria—In accordance with the F&OR, these facilities shall include craft shops, heavy equipment maintenance and vehicle maintenance and motor pool.

1. Craft Shops, Area 71A—This information supplied later.

2. Heavy Equipment Maintenance Facility, Area 220—This information supplied later.

3. Vehicle Maintenance and Motor Pool, Area 690—This facility provides space for a wash bay, five maintenance bays, material and equipment storage, and associated office space and rest rooms.

4. Equipment/Yard Storage, Area 71B—This area provides space for a equipment parking and storage in an open area with small equipment enclosures as required.

Technical Rationale—The selected configuration, materials, and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.

H. Central Control Center Facility(CCCF), Area 240

Criteria—As required in the F&OR, the Central Control Center Facility (CCCF) shall provide two primary functions: plant-wide monitoring and control systems and plant-wide safeguards and security. This facility provides functional space and layout for the central control center and safeguards systems.

The CCCF consists of a concrete structure with controlled access. The primary alarm station shall have one HVAC system and electrical system. The central control center and central communications room share another HVAC system and electrical system. The detailed design of this facility will be determined based on input from safeguards and security, functional, and operational requirements as they are developed.

Technical Rationale—The selected configuration, materials, and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.

4.2.3.3 Design of Architectural Works

Criteria—The design and construction of the repository surface facilities shall incorporate standard materials and practices appropriate for the specific building type and facilitate a 50-yr operational life. The design shall be defensible in terms of scope, cost, and appearance. A defensible design has good planning, effective function, simple form, cost-effectiveness, contractibility, adaptability, durability, cleanability, a clean appearance, and maintainability.

Technical Rationale—The architectural design philosophy represents good practice in the approach to architectural features for the types of buildings planned.

4.2.3.3.1 General Considerations

Criteria—Design of the facilities shall reflect design characteristics developed for the repository project complex and considers form, function, constructability, durability, cleanability, and cost effectiveness. All facilities have a 50-year design life and incorporate neutral colors that blend with the visual or aesthetic impact on the surrounding environment. All structures include the following elements as appropriate to the specific consideration of the buildings magnitude and design:

A. Exterior materials shall include variations of material types such as precast concrete, reinforced cast-in-place concrete, concrete masonry units, or metal siding.

B. Interior finishes and wall types have durable, easily cleaned surfaces. Finish types and colors have a standardized appearance throughout the project facilities depending on specific area function. Determination of wall types depends on fire protection requirements, function, durability, shielding, and other factors.

C. Component features of exterior elements including color, profile, design, and textures look similar throughout the project complex.

D. Material products, product salient features, sizes, and manufacturers (where necessary) remain consistent for ease of procurement and maintenance. Items of particular importance include siding systems, roofing systems, interior finish materials, doors and hardware or keying, signage, elevators, platforms, handrails, and plumbing fixtures. Interior and exterior areas subject to equipment movements and operations of potential impact have durable materials.

Technical Rationale—Architectural design philosophy represents general good practice in approaching architectural features for types of buildings planned on this site.

4.2.3.3.2 Types of Occupancy and Construction

Criteria—The repository facilities shall comply with occupancy classifications and construction types identified in the IBC (ICC 2000 [DIRS 159179]); however, occupancy loads for determining life safety means of egress also comply with NFPA 101®-2003, *Life Safety Code®* [DIRS 165076]. The occupancy classifications and construction types for each facility identified in the F&OR appear in Table 4.2.3-1.

Table 4.2.3-1. International Building Code Occupancy Classification and Construction Type

Building/Facility Name	Total Building Area sq ft (approx.)[a]	IBC Use and Occupancy Classification	IBC Type of Construction
North Portal Facilities			
Canister Handling Facility	139,000	F-2	I B
Transportation Cask Receipt/Return Facility, Waste Package Receipt Facility and Warehouse and Non-Nuclear Receipt Facility	85,500	F-2, B and S-2	II B
Dry Transfer Facility 1	620,000	F-2	I B

Table 4.2.3-1. International Building Code Occupancy Classification and Construction Type (Continued)

Building/Facility Name	Total Building Area sq ft (approx.)[a]	IBC Use and Occupancy Classification	IBC Type of Construction
Dry Transfer Facility 2	Future	F-2	I B
Fuel Handling Facility	115,000	F-2	I B
BOP Facilities			
Administration Facility, including Emergency Operations Center	63,000	A-2	II B
Central Control Center Facility	Future	B	I B
BOP Security Facilities			
Administration Security Station (North)	150	B	II B
Administration Security Station (South)	150	B	II B
Central Security Station	12,500	B and U	II B
Cask Receipt Security Station	Future	B and U	II B
North Perimeter Security Station	150	B	II B
Utilities Facilities			
Utilities Facility	33,000	F-2	II B
Cooling Tower	Future	Future	Future
12.47 kV Switchgear Facility	2,700	F-2	II B
4.16 kV Switchgear Facility	3,800	F-2	II B
Emergency Generator Facility	2,300	F-2	II B
Standby Generator Facility	4,000	F-2	II B
Fire Water Facility	Future	F-2	II B
Switchyard	Future	Future	Future
Storm Water Retention Pond	Future	Future	Future
Evaporation Pond	Future	Future	Future
Emergency Response Facilities			
Fire, Rescue, and Medical Facility (Operations)	18,000	B	II B
Helicopter Pad Facilities (operations)	Future	Future	Future
Offsite Facilities			
Visitor Center	Future	A-2	II B
Offsite Training Facility	Future	Future	Future
Gate 510 Facilities	Future	Future	Future
Emergency Management Center	Future	Future	Future
Materials and Consumables Facilities			
Warehouse/Central Receiving	22,000	S-2	II B
Fuel Depot	8,500	M	II B
Diesel Fuel Oil Storage	Future	Future	Future
LLW Handling	Future	N/A	Future
Hazardous Materials Collection	Future	N/A	Future
Non-Radiological/Non-Hazardous Materials	Future	N/A	Future
Maintenance and Repair Facilities			
Craft Shops	19,000	S-1, S-2, and B	II B
Heavy Equipment Maintenance Facility	57,000	S-1 and B	II B
Vehicle Maintenance and Motor Pool	19,000	S-1 and B	II B

Table 4.2.3-1. International Building Code Occupancy Classification and Construction Type (Continued)

Building/Facility Name	Total Building Area sq ft (approx.)[a]	IBC Use and Occupancy Classification	IBC Type of Construction
Transportation Facilities			
Truck Staging Area	Future	Future	Future
Rail Car Staging Area	Future	Future	Future
Personnel Transportation (shuttle stop)	Future	Future	Future
Construction Support Facilities			
South Portal	Future	Future	Future
North Portal	Future	Future	Future
	Other Facilities		
Infrastructure (general)	Future	Future	Future

NOTE: [a] Areas represent an approximation of space requirements and are subject to review and revision based on the final space needs requirements developed at the time of final design.

Technical Rationale—The IBC occupancy classification and construction type summary represents general good practice in approaching architectural features for types of buildings planned on this site.

4.2.3.3.3 Means of Egress

Criteria—Means of egress for all surface facilities shall provide continuous recognizable path of travel from all areas to public way - via approved exit access, exit enclosure and exit discharge.

Stairs and ladders provided for fire egress and equipment access provide safe and continuous path of travel from all areas to an approved exit access. Design requirements include all features of stairs, ladders, and alternating tread devices such as rise, run, width, landings, maximum landing obstruction, guardrails, handrails, and toe boards.

This section does not pertain to subsurface facilities.

Technical Rationale—Means of egress and ladders and stairs comply with requirements of NFPA 101®-2003 [DIRS 165076] and 29 CFR Part 1910 [DIRS 172709] for requirements.

4.2.3.3.4 Fire Protection

Criteria—Buildings fire barriers shall provide continuous separation of zones to the extent required for fire and life safety as defined in applicable codes and standards.

Technical Rationale—Fire barriers shall comply with applicable sections of the IBC (ICC 2000 [DIRS 159179]), NFPA 101®-2003 [DIRS 165076], and NFPA 801-2003, *Standard for Fire Protection for Facilities Handling Radioactive Materials* [DIRS 165077], and requirements of fire barriers and noncombustible or fire-resistive construction materials as described in the Fire Hazard Analysis and in Section 4.8.1.19.

Criteria—Exposed interior wall and ceiling finish materials and any factory installed facing materials shall limit flame spread and smoke development to a code approved flame spread rating specified in Section 4.8.1.12.3.

Technical Rationale—Interior finishes and materials meet the most restrictive criteria specified in Section 4.8.1.12.3.

4.2.3.3.5 Energy Conservation

Criteria—All facilities shall comply with the energy conservation requirements set forth in ANSI/ASHRAE/IESNA Std 90.1-2004 [DIRS 174321]. Other energy conservation measures shall include the following items:

- Exterior windows in air-conditioned buildings shall meet shading coefficient requirements by means of tinted insulated glass.
- Personnel, equipment, and vehicular exterior access doors in air-conditioned buildings shall have insulation.
- Exterior openings shall have adequate weather-stripping to minimize air infiltration and exfiltration.
- Exterior insulated metal siding walls shall have double caulking to minimize air leakage.
- All entrances of occupied buildings shall have vestibules to serve as airlocks and to maintain positive or negative air pressure, as appropriate. Allowable infiltration and exfiltration shall comply with ANSI/ASHRAE/IESNA Std 90.1-2004 [DIRS 174321], except where building or process operations require more stringent provisions to maintain differential pressure.

Technical Rationale—The design uses good engineering practice in addition to ANSI/ASHRAE/IESNA Std 90.1-2004 [DIRS 174321] requirements to produce the maximum energy conservation.

4.2.3.3.6 Accessibility

Criteria—All buildings and adjoining site areas, including parking and building access, shall comply with the IBC (ICC 2000 [DIRS 159179]), ICC/ANSI A117.1-1998 [DIRS 158846], and applicable provisions of the Americans with Disabilities Act of 1990 [DIRS 162264].

Technical Rationale—All facilities require accessibility in accordance with applicable provisions of the IBC (ICC 2000 [DIRS 159179]), ICC/ANSI A117.1-1998 [DIRS 158846], and Americans with Disabilities Act [DIRS 162264].

4.2.3.3.7 Building Envelope

Criteria—Exterior walls shall consist of cast-in-place concrete, tilt-up concrete panels, precast concrete, or prefinished metal siding as described as follows:

- Roofing systems shall consist of prefinished metal or single ply roofing. All facility roofs have standard roof drains, overflow roof drains, and exterior scuppers and downspouts with concrete splash blocks. Roof drainage systems have adequate size to accommodate rainfall criteria per Section 6.1.1.1.

- Wall systems, including penetrations, flashing, accessories, doors, and windows, shall have air and water infiltration seals and fire rated penetration materials and constructions where required. Energy conservation design and construction shall comply with Section 4.2.3.3.5.

- Exterior walls shall have fire resistance and opening protection, as required, in accordance with the IBC (ICC 2000 [DIRS 159179]). These IBC requirements include those given in Tables 601 and 602 in addition to those given in the IBC (ICC 2000 [DIRS 159179], Section 704).

- Exterior wall, door, regulator assemblies, and exterior roof systems can withstand wind and wind-driven missile design loads as specified in the repository structural design criteria on a facility-by-facility basis.

Technical Rationale—The building envelope configurations conforms to good architectural and structural practices for the operational life expectancy indicated in Section 4.2.3.3.1. They also comply with energy conservation and fire resistive standards and have the capability to withstand and resist high wind and wind-driven missiles.

4.2.3.3.8 Decontamination and Decommissioning

Criteria—Architectural requirements for decontamination and decommissioning shall include finishes, coatings, and material selection.

Technical Rationale—Coating requirements in radioactive material processing areas or areas where radioactive material is stored are non-porous for ease of decontamination.

4.2.3.3.8.1 Interior Finishes and Coatings

Criteria—Interior finishes in areas used for processing or storing radioactive materials and those areas having a possibility of radioactive contamination of wall, ceiling, or floor surfaces shall have non-porous surfaces for ease of decontamination per NFPA 801-2003 [DIRS 165077], Paragraph 3-8. Potentially contaminated areas not provided with stainless steel cladding, and areas requiring high durability, or liquid containment areas have special protective coatings. Coating type and thickness can vary as determined through analysis on an area-by-area basis.

Technical Rationale—Coating requirements in radioactive material processing areas or areas where radioactive material is stored have non-porous surfaces for ease of decontamination.

4.2.3.3.8.2 Material Selection

Criteria—The repository design shall comply with the objectives of permanent closure and decontamination, or decontamination and dismantlement. The design meets this requirement if design includes, where feasible and economical, choices that support closure and decontamination, or decontamination and dismantlement over competing alternatives.

Examples of favorable design features include the following:

1. Selection of materials and processes to minimize waste production
2. Minimization of the mass of shielding materials subject to neutron activation
3. Use of modular design and inclusion of lifting points to facilitate removal and dismantlement
4. Selection of materials for compatibility with projected closure and decontamination, or decontamination and dismantlement, or waste processing procedures
5. Use of minimum surface roughness finishes on SSCs that have potential for contamination
6. Use of coatings that preclude penetration into porous materials by radioactive gas, condensate, deposited aerosols, or spills, to permit decontamination by surface treatment
7. Incorporation of features to contain leaks and spills
8. Incorporation of waste minimization techniques
9. Incorporation of features that would maintain occupational and public radiation doses as low as is reasonably achievable (ALARA) during decommissioning.

Technical Rationale—The design complies with NUREG-1804 (NRC 2003 [DIRS 163274]), Section 2.1.3.2, Review Method 1; and Regulatory Guide 8.8, *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable* [DIRS 103312], Sections C.1.d, C.2.d, and C.2.f.

4.2.3.3.9 Plumbing Fixtures

Criteria—Restrooms, shower areas, and office areas shall have, at the least, minimum quantities of plumbing fixtures required by *International Plumbing Code, 2000* (ICC 2000 [DIRS 159180]). Fixtures shall include restroom lavatories, water closets, drinking fountains, urinals, showers, service sinks, lunchroom sinks, and health physics lavatories.

Technical Rationale—The design complies with good engineering practice and the standards of *International Plumbing Code, 2000* (ICC 2000 [DIRS 159180]) identify minimum quantities of plumbing fixtures.

4.2.3.3.10 Security/Access Control

Criteria—The design shall provide security access and control features. The detailed design phase of the project shall address specialty door hardware, windows, surveillance at the entrance of the building, and other architectural building features required for repository facility security.

Technical Rationale—Security and access control requirements represent good architectural practices and comply with safeguard and security criteria as it develops.

4.2.3.3.11 Penetrations and Seals

Criteria—Penetrations and seals shall provide closure to the extent required by applicable codes standards and operational requirements. Section 4.8.1.19 describes design guide requirements responsibilities for penetrations and seals.

Technical Rationale—Architectural material requirements represent good architectural practices in architectural design.

4.2.3.4 Architectural Material Requirements

Criteria—The building exterior system and penetrations, copings, covers, louvers, and trim pieces shall produce weather tight durable enclosures in accordance with applicable codes and standards.

Technical Rationale—Architectural material requirements represent good architectural practices in architectural design.

4.2.3.4.1 Exterior Walls, Windows, and Louvers

Criteria—Exterior wall and roof system assemblies shall consist of compatible components of the same manufacturer, where possible. Exterior windows, glass, and glazing shall consist of manufacturer standard fabrication and sizes. Exterior metal louver size and construction shall meet airflow requirements determined by HVAC and other criteria identified within this document.

A. **Concrete Masonry Units**—Concrete masonry unit exterior wall construction consists of medium-weight standard block as indicated in Section 4.2.3.3.1A. Units shall have reinforcing steel and solid grout fill in areas required for wind-driven missile protection or as required for reinforced cells.

B. **Composite Metal Wall System**—Field-assembled composite metal wall panel system shall consists of a field-assembled composite metal liner panel and an exterior metal panel on metal purlins or girts with fiberglass or polystyrene insulation in the cavity. Other related system components include flashing, sealant, clips, coping, subgirts, fasteners, panel closure, and gaskets. R-value for composite wall system has R-19 or greater thermal resistance.

Exterior panels shall consist of factory finished, galvanized metal.

Interior liner panels shall consist of factory finished, galvanized metal, flat profile panels with 1-1/2 in. "z" shape subgirts or channels.

Metal louvers shall consist of factory finished galvanized metal, 45-degree blades with center baffles, and return bend for weather protection and bird screen.

C. **Metal Sandwich Wall System**—The factory-assembled metal sandwich panel system shall consist of a factory-assembled metal sandwich panel system that resembles the components in the composite metal wall system. The R-value for exterior wall system has R-21 or greater thermal resistance.

Exterior panels shall consist of factory finished sheet metal of at least 24-gauge galvanized steel.

Metal louvers used with this system shall match toe system finish and consist of factory finished galvanized sheet metal with 45-degree blades, center baffles, and return bend for weather protection and bird screen.

D. **Entrance doors, glass, glazing, and exterior windows entry doors**—Entrance doors, glass, glazing, and exterior windows shall have insulated glazing and tempered glazing where required. Window frames shall have thermal breaks fixed. Glazing shall consist of two lites separated by ½-inch hermetically sealed dehydrated air space and consist of ¼-inch clear glass interior, and ¼-inch tinted "low E" glass on the exterior side similar to Pittsburgh Plate Glass "Graylite." Main entry doors to facilities that are accessible to the public shall consist of storefront type aluminum frames with clear anodized finish.

Exterior windows shall consist of aluminum frames with clear anodized finish. Main entry doors shall have a storefront type aluminum frame with clear anodized finish. Window glazing shall have an exterior lite with a tint similar to Pittsburgh Plate Glass "Graylite."

The building envelope shall meet the Nevada Energy Code insulation R and U values that depend on detailed design.

E. **Precast Concrete Walls**—Information to be provided later.

F. **Cast-in-Place Concrete Walls**—Information to be provided later.

G. **Tilt-up Concrete Panels**—Information to be provided later.

Technical Rationale—Architectural material requirements represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.2 Roofs

Criteria—Roof assemblies shall comply with the Class B standards in ASTM E 108-04, *Standard Test Methods for Fire Tests of Roof Coverings* [DIRS 173416], NFPA 256-2003, *Standard Methods of Fire Tests of Roof Coverings* [DIRS 173417], and UL 790-2004, *Standard for Standard Test Methods for Fire Tests of Roof Coverings* [DIRS 173419], or Class I standards in FM 4471-1995, *Approval Standard for Class I Panel Roofs* [DIRS 173418]. Roof systems use commercial grade materials and consist of compatible components as recommended by the roofing manufacturer. Roof application complies with the guidelines indicated in the manual, which have been identified and are being procured. Roof insulation for all repository facilities shall have a minimum resistance value of R-30. Metal roofing complies with Factory Mutual Class I or Underwriters Laboratory (UL) Class B requirements. All process building main roofs and other roofs with mechanical equipment have roof access by means of ladders, hatches, or stairs complying with OSHA standards. Roofs requiring access to roof mounted mechanical equipment shall have walkways. Walkways within 10 feet of roof edges have fall protection by means of guardrails. Other areas have fall protection by means of safety harness.

Roofing systems may comply with one or more of the following systems:

A. **Standing Seam Metal Roof System**—The system includes panels, polyisocyanurate rigid insulation, structural deck sub-purlins, clips, flashing, roof drain pans, sealant, and accessories that provide for a complete system with at least 1/4 in. per ft slope. Roofs have a manufacturer's standard color.

B. **Single Ply Roof System**—This system includes membrane, insulation, vapor barrier, flashing, expansion joints, pedestals and curbs, mechanical equipment curbs, sealant, roof drains and overflow roof drains, drainage scuppers or gutters, downspouts, roof drain leaders, accessories and appurtenances necessary to provide a complete system meeting the industry standards for roofing applications and the requirements of this architectural criterion. Single ply roof system consists of roof membrane fully adhered to rigid board insulation fully adhered or mechanically fastened to metal decking with at least 1/4 in. per ft slope. Roofs have a manufacturer's standard color.

Technical Rationale—The roof systems described represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.3 Doors and Hardware

Criteria—Exterior and interior personnel doors, service doors, and vehicle doors shall have frames, hardware and fittings suitable for the purpose intended. Descriptions and requirements for shielding and special doors for operations appear elsewhere in this document. Exterior door assemblies and roll-up doors, including the frame, shall have the capability to withstand wind loads as required in Section 4.2.3.3.7. Doors and frames for openings in fire-rated barriers shall bear UL or Factory Mutual labels appropriate for each fire-rated wall opening. Design and installation of fire doors shall meet National Fire Protection Association (NFPA) standards identified in Section 4.8.1. Doors at ventilation zone boundaries shall have appropriate seals;

doors in areas where adverse ventilation conditions may impair normal egress shall have pressure equalization devices and hardware that do not restrict exiting.

A. **Exterior Personnel Openings**—Exterior personnel openings shall have 1-3/4-in. insulated hollow metal doors, flush face, at least 16-gauge material. Exterior door frames shall have hollow metal steel, at least 14-gauge material. Doors shall have lockable entrance hardware; exit or panic hardware where required; weather-stripping; door sweep; threshold; closer; and other associated hardware. These doors have an R-value of not less than 2.

B. **Interior Personnel Openings**—Interior personnel openings in operational areas shall have flush face, 1-3/4-in. hollow metal doors, and at least 18-gauge material. Doors in office or similar support areas may consist of solid core wood with wood or laminate veneer. Where required for visibility, doors shall have wired glass vision panels. Door frames shall be hollow metal steel, at least 16-gauge material. Doors shall have appropriate hardware.

C. **Interior Overhead Coiling Service Doors**—Interior overhead coiling service doors shall have interlocking slat roll-up type, top coiling with dust hood, and manual operation. Overhead coiling doors over 100 sq ft in area shall have motor operators. Other overhead coiling service doors and vehicular doors shall have insulation and weather stripping.

D. **Sliding, Overhead Sectional, Vertical Lift, and Overhead Coiling Doors**—Sliding, overhead sectional, vertical lift, and overhead coiling doors shall have motorized operators and have the capability to withstand specific building seismic and wind requirements identified in Sections 4.2.2 and 4.2.3.3.7.

E. **Door Hardware**—Door hardware shall meet the requirements for the door function, code, and underwriters fire label requirements. Door hardware shall meet the appropriate American National Standards Institute (ANSI) standard. All hardware finishes shall be brushed chrome finish. Locksets and latch sets for all doors except special doors specified by other disciplines, shall have lever handles meeting ANSI and IBC accessibility requirements. Locksets shall consist of the mortise type with interchangeable cores, six pin tumbler cylinders with Corbin 59C2-6 keyway for each lockset, unless otherwise indicated. All lock keying shall match the project master and grand master keying system. Hardware shall have the UL listing for fire-rated doors.

Technical Rationale—The doors and frames systems described represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.4 Interior Partitions

Criteria—Interior partitions include non-bearing walls consisting of reinforced concrete, reinforced concrete masonry units, and metal stud and gypsum board construction. Steel studs shall have a C-shaped section and punched webs. Walls required for fire barrier assemblies shall meet UL rated fire-resistive standards including penetration protection as required. Partition construction shall consists of reinforced concrete construction, reinforced grout filled concrete masonry units, or gypsum board on metal studs. Where required to shield areas of liquids or bulk materials, or for operational durability, concrete construction will be used.

Gypsum board walls shall have metal studs with 5/8-in. type X gypsum board on each side, layered as required for fire rating. Gypsum board walls along corridors within process areas shall have an impervious smooth surface wainscot to a height of at least 6 ft above the finished floor or as needed for moveable equipment protection. Bulk materials storage areas and areas that need operational durability will use reinforced concrete masonry unit construction. Computer rooms, reproduction rooms, and high noise-level areas separated from occupied areas shall have full height partitions with sound insulation.

Sound transmission class (STC) ratings refer to measurements of specific partition construction for reducing airborne sound. Minimum sound isolation requirements for separation of source room from adjacent receiver room are as follows:

- Offices, conference rooms, computer rooms, and restrooms—STC 50
- Mechanical room near occupied areas—STC 65.

The design and materials of the beams, floors, roofs, columns, walls, and partitions shall comply with *Fire Resistance Directory 2003* (UL 2003 [DIRS 167310]).

Technical Rationale—The interior partitions comply with good engineering practice for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.5 Flooring

Criteria—Flooring systems shall include stainless steel liners, special protective coatings, vinyl composition tile, sheet vinyl, ceramic tile, carpet, raised access flooring, and sealed concrete.

- Where the potential threat of water or liquid damage is possible, floors slope to a sump or drain.

- Process and service floors involving radioactive materials, including ventilation areas that have contamination classifications, have special protective coatings to facilitate decontamination. These special coatings extend up the walls to form a base 6 in. tall.

- Lunchrooms, offices, corridors, and other similar spaces where contamination classification is not required have vinyl composition tile.

- Non-contaminated change room areas have sheet vinyl with a 6-in. coved vinyl base. Restroom and shower areas have ceramic tile floors and wainscot.

- Laboratory areas have chemical-resistant floor systems. Computer areas have raised access floor systems consisting of 24-inch square steel panel modules. The panel finish is carpet tile.

- Non-radioactive materials usage areas of exposed construction requiring heavy equipment usage, such as shops and mechanical and electrical equipment rooms, have concrete floors with hardener and sealer finish.

- Floor finishes have Class I rating when tested in accordance with the IBC (ICC 2000 [DIRS 159179]) and have a critical radiant flux of 0.45 W/sq cm minimum.

- Floor surfaces have a slip resistance rating of 0.5 in accordance with the ASTM standard for the type of flooring selected.

- The Administration Building shall have carpet with rubber base throughout offices and similar areas. Lobbies may employ high traffic coatings (i.e., ceramic or porcelain paver tile with appropriate base material). Lunchrooms, workrooms, janitor closets, and similar spaces shall have sheet vinyl flooring with rubber base. Restrooms shall have ceramic tile with ceramic tile wainscot.

Technical Rationale—The flooring systems described represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.6 Ceilings

Criteria—Non-contaminated areas of occupied facilities, including offices, conference rooms, computer rooms, change space rooms, restrooms, and associated lobbies and corridors, shall have suspended acoustical lay-in panel system ceilings with a 2- by 4-ft tee-bar grid. Shower areas and janitor closets shall have painted suspended gypsum board ceilings. Finished ceiling heights equal 9 or 10 ft in offices, corridors, laboratories, and similar areas and 9 ft in restrooms and shower rooms. Ceiling systems shall have integrated lighting, partitions, fire sprinklers, HVAC, and related building systems.

Occupied or unoccupied areas without ceilings shall have exposed construction finished with coatings as described in Section 4.2.3.4.7. These areas include subchange rooms, storage areas, shops, mechanical and electrical areas, janitor rooms, and similar spaces.

Technical Rationale—The ceiling systems described represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.7 Architectural Finishes

Criteria—Finishes used throughout the repository facilities shall meet fire-resistive requirements identified in Section 4.2.3.3.4B. Areas within facilities that contain radioactive materials and processes or have potential of radioactive contamination shall receive special protective coatings selected for the specific area environment. Areas that require radiation tolerance, chemical resistance (e.g., decontamination process), temperature resistance, resistance to flame spread and smoke generation, fire resistance (fireproofing), interior finish (specifically excluding equipment and piping), and potential mechanical abuse may need special protective coatings. These coatings shall facilitate decontamination and decommissioning.

Industrial areas without radioactive materials and processes shall have conventional coatings to maintain cleanliness and adequate illumination levels for safety and work efficiency. Offices, conference rooms, corridors, computer rooms, restrooms, and similar spaces shall receive semi-gloss paint finishes or other paint finish, where applicable.

Technical Rationale—The architectural finishes described represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.8 Architectural Specialties

Criteria—Minimum specialties used in repository facilities shall include visual display boards, projection screens, metal toilet partitions, shower compartments, corner guards, identifying devices, lockers, fire extinguisher cabinets, cubicle curtains, and toilet and bath accessories. Other architectural accessories will be identified during design.

The following standards will apply throughout unless noted otherwise:

- Lunchrooms, conference rooms, and other rooms used for meetings shall have visual display boards. Display boards shall be white dry-erase writing surfaces or electronic that can be controlled from a central location.

- Main conference rooms shall have projection screens. Screens shall be matte white or glass bead surface with a 60-in. square screen or the screen size appropriate to the room size.

- Each water closet shall have a metal toilet compartment and each urinal shall have a metal visual screen. Toilet compartments shall have baked enamel finish on steel, floor attached, overhead bracing complete with chrome steel hardware and accessories. Urinal screens shall have baked enamel finish on steel, wall supported, with concealed wall supports and hardware.

- Each showerhead shall have a separate shower compartment. Compartments shall include shower and dressing areas and have a baked enamel finish on steel, floor attached, overhead bracings, with an integral bench, a curtain rod with snap hooks, and a heavy plastic curtain. Showers may have a ceramic tile surround substituted for metal compartment with a metal dressing area compartment.

- Corridor corners shall have corner guards where operations use moveable carts or equipment, or in heavy traffic areas. Corridors within office-type areas do not require corner guards. Guards shall resist impacts of a minimum 25.4 ft-lb/in.^{2}, Izod test, per standard. Standard tile and number are to be added later.

- Identifying devices throughout the repository complex facilities shall comply with the Americans with Disabilities Act [DIRS 162264]. Signage includes main entry signs, emergency exit signs, area identification signs, room signs, emergency exit signs, and main directory sign.

- Change rooms shall have metal lockers 12-in. wide by 15-in. deep of single tier with sloping top. Benches shall be 12 in. wide.

- The repository facilities shall have fire extinguishers with cabinets in quantities and locations required by *Standard for Portable Fire Extinguishers* (NFPA 10-2002 [DIRS 160950]).

- Personnel decontamination rooms shall have cubicle curtains for personnel privacy. Curtain assemblies shall consist of a surface mounted aluminum cubicle track, metal bead chain and hook assembly with nylon axle, and a 5-1/2 ounce per square yard fire retardant cotton cloth curtain that complies with flame spread/smoke index rating for this project.

- Restrooms, shower rooms, and janitor closets shall have toilet and bath accessories.

- Accessories shall have a satin chrome steel finish and include paper towel dispensers, lavatory mirrors, liquid soap dispensers, sanitary napkin dispenser, toilet seat cover dispensers, sanitary napkin disposals, robe hooks, and mop holders.

Technical Rationale—The architectural specialties described represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.9 Fixed Equipment

Criteria—Fixed equipment shall include general casework and countertops, laboratory casework and worktops, laboratory storage casework, work clothes storage bins, main entry mats, and exterior window blinds.

The following standards apply unless noted otherwise:

- Lunchrooms, workrooms, health physics rooms, and other similar spaces shall have general casework including lower and upper cabinetry, countertops, and splashes.

- Casework shall have plastic laminate faces mounted on high-density particleboard with a splash.

- Laboratories shall have laboratory casework and storage units. Casework shall include lower and upper cabinetry and chemical resistant laboratory worktops with an integral splash.

- Main and subchange rooms, and laundry storage rooms for the storage of clean work clothing shall have work clothes storage bins. Bins shall have plastic laminate faces mounted on high-density particleboard.

- Main entrances shall have fixed recessed entry mats with aluminum frame.

- Fixed exterior windows in offices and lunchrooms shall have window blinds. Blinds shall be 1-in. horizontal aluminum louvers with full tilt and lift controls.

Technical Rationale—The fixed equipment described represents good architectural practices.

4.2.3.4.10 Conveying Equipment

Criteria—Conveying equipment shall include personnel elevators, freight elevators, and dumb waiters. Size of conveying equipment depends on need and function, including dimensions and load requirements.

Technical Rationale—Conveying equipment depends on the specific needs of each facility.

4.2.3.4.11 Plumbing Fixtures

Criteria—Plumbing fixtures shall include water closets, urinals, restroom lavatories, showers, service sinks, lunchroom sinks, health physics lavatories, electric water coolers, and emergency eyewash and shower stations.

The following standards will apply throughout unless noted otherwise:

- Water closets consist of wall-hung type, with elongated vitreous china bowl, molded composition split seat, with water closet support carrier and automatic flush valves operation (1.6 gal per flush). Pipe chase sizes provide for the installation of piping, carriers, and insulation material, if required.

- Urinals consist of wall-hung type with vitreous china bowl with support carrier and automatic operated flush valve (1 gallon per flush).

- Restroom lavatories consist of wall-hung type or counter-mounted type, vitreous china bowl with splash lips, and front overflow, complete with anti-scald faucet (2.2 gal/min maximum) and provisions for soap dispenser.

- Showers consist of single occupancy floor receptor with concealed water supply, drainage, and vent piping. Walls and floors comply with Section 4.2.3.4.8. Showers have single lever type shower valves (2.5 gal per minute maximum) with anti-scald mixer and vandal-proof showerheads.

- Service sinks consist of wall-hung type acid-resisting enameled cast iron bowl with wall hanger.

- Faucets in janitor closets consist of service-type with integral bucket hook and hose connection.

- Each lunchroom has a double bowl sink with appropriate fixtures.

- Faucets have 2.2 gal per minute maximum flow.

- Each personnel decontamination room has a single bowl stainless steel lavatory with an associated trim (2.2 gal per minute maximum).

- Water coolers consist of wall mounted metal electrically refrigerated units with adjustable stream regulator.
- Emergency eyewash and shower comply with ANSI Z358.1-2004 [DIRS 173120].
- All plumbing fixtures and trim comply with ICC/ANSI A117.1-1998 [DIRS 158846].

Technical Rationale—The plumbing fixtures described represent good architectural practices for the operational life expectancy indicated in Section 4.2.3.3.1.

4.2.3.4.12 Lighting

Lighting criteria to be provided later.

4.2.4 Subsurface Structural Design Criteria

4.2.4.1 Subsurface Structural Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Civil/Structural/ Architectural	Structural[b]	ACI 318-02/318 R-02, ACI 349-01, AISC 1997, ANSI/AISC 341-02, ANSI/AISC N690-1994, ASCE 4-98, ASTM A 307-00, ASTM A 325-02, ASTM A 36/A 36M-04, ASTM A 490-02, ASTM A 500-01a, ASTM-A 588/A 588M-03, ASTM A 615/A 615M-01b, ASTM A 706/A 706M-01, ASTM A 759-00, ASTM A 992/A 992M-02, AWS D1.1/D1.1M:2002, ICC 2000 [DIRS 159179]
		NUREG-0800 (NRC 1987), NUREG-0800 (NRC 1989 [DIRS 165111]), Regulatory Guide 1.61
		10 CFR Part 63, 29 CFR Part 1910, 29 CFR Part 1926
		DOE-STD-1020-2002

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21 (c)(2) [DIRS 173273]), PRD-022, and the Subsurface Facility. Applicable sections of this document will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in these regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides. Addressing these regulatory guides supports compliance with requirements for the Subsurface Facility.

[3] Addressing CFRs supports compliance with requirements for the Subsurface Facility, PRD-015/P-015, PRD-015/P-020, PRD-015/P-021, and PRD-005.

[4] Addressing the DOE Standard supports compliance with requirements of PRD-018/P-019. Applicable sections of this DOE Standard will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.2.4.2 Site Information

4.2.4.2.1 General

The YMP site is located in Nye County, State of Nevada, approximately 100 miles northwest of the city of Las Vegas.

4.2.4.2.2 Rock Properties

For rock properties, see *Subsurface Geotechnical Parameters Report* (BSC 2003 [DIRS 166660]).

4.2.4.2.3 Seismology

Criteria—Yucca Mountain site-specific acceleration time histories and associated acceleration response spectra at the repository elevation and at the rock surface above repository elevation shall be those referenced in Section 6.1.3.

Technical Rationale—The YMP is committed to using site-specific ground motion.

4.2.4.2.4 Groundwater

Criteria—The water table is estimated to be over 1,000 ft below the North Portal and repository horizon. Although local and perched water may be encountered, environmental design conditions for the drifts and shafts shall be maintained dry.

Technical Rationale—The water table is determined based on site investigations per *Hydrogeologic Framework Model for the Saturated-Zone Site-Scale Flow and Transport Model* (BSC 2004 [DIRS 170008]). Also see Sections 4.11.2.2.3 and 4.11.2.2.4.

4.2.4.3 Seismic Categorization of Structures, Systems and Components

Criteria—Seismic categorization of SSCs shall be described in Section 4.2.2.2.

All SSCs located underground shall be designed to seismic ground motions as applied to the repository elevation during a site-specific 2,000-year return period seismic event. The vertical and horizontal ground motions acceleration spectra to be applied to SSCs located underground at Point B are provided in Section 6.1.3.

Subsurface facility SSCs located on the surface shall be designed per criteria stated in Section 4.2.2.

The seismic design bases for the subsurface facility SSCs are summarized in Tables 4.2.4-1 and 4.2.4-2.

Table 4.2.4-1. Seismic Design Basis for Structures, Systems, and Components

SSCs	Seismic Design Basis
Steel Invert Structures in Emplacement Drifts	2,000-year return period
Transfer Dock Structures in Turnouts	2,000-year return period
Isolation Barriers, Steel Bulkheads, and Emplacement Access Doors in Access Mains, Exhaust Mains, and Turnout	2,000-year return period
Concrete Invert Structures in Turnouts, Access and Exhaust Mains	2,000-year return period
Muck Handling Facilities	IBC Seismic Use Group I
Steel Platforms and Walkways at Repository Elevation	2,000-year return period
Supports for the Utilities	2,000-year return period
Shaft Collars	2,000-year return period
Portal Structures and Foundations	IBC Seismic Use Group II
Miscellaneous Structures and Foundation Pads at Rock Surface above Repository Elevation	IBC Seismic Use Group II

Table 4.2.4-2. Seismic Use Group and Importance Factors of Structures, Systems, and Components Designed to International Building Code

Seismic Use Group	Importance Factor, I	SSCs Designed to International Building Code
I	1.0	Conventional SSCs for standard occupancy
II	1.25	SSCs that represent substantial hazard to human life
III	1.5	Essential or hazardous SSCs

Table 4.2.4-3 provides a summary of the structural design codes and standards that apply to different seismic category SSCs.

Table 4.2.4-3. Applicability of Design Codes and Standards to Seismic Categories

Title	Applicability	Safety Category (SC) SSCs	Conventional (Non-SC) SSCs
ICC 2000 [DIRS 159179] International Building Code	Seismic Design		X
ASCE 4-98 [DIRS 159618] Seismic Analysis of Safety-Related Nuclear Structures and Commentary	Seismic Analysis	X	
ACI 349-01 [DIRS 158833] Code Requirements for Nuclear Safety-Related Concrete Structures	Design of Concrete Structures	X	
ACI 318-02/318R02 [DIRS 158832] Building Code Requirements for Reinforced Concrete	Design of Concrete Structures		X
ANSI/AISC N690-1994 [DIRS 158835] Steel Safety-Related Structures for Design, Fabrication, and Erection	Design of Structural Steel	X	
AISC 1997 [DIRS 107063] Manual of Steel Construction, ASD	Design of Structural Steel		X
ANSI/AISC 341-02 [DIRS 171789] Seismic Provisions for Structural Steel Buildings	Seismic Detailing of Structural Steel (Part III)	X	X

Technical Rationale—For SSCs that are ITS, the seismic categorization is in accordance with site-specific seismic ground motion. For conventional SSCs, seismic categorization is in accordance with industry standards.

4.2.4.4 Materials

Criteria—The use of materials in the emplacement drifts shall be limited to those that do not have an adverse effect on postclosure performance. The use of materials in the emplacement drifts is currently limited to steel and ballast. Any other materials shall not be allowed for use until appropriate testing and modeling work is done with respect to potential affects on postclosure performance. Materials other than those specified above may be used in the nonemplacement drifts.

Technical Rationale—Steel and ballast are the committed materials in emplacement drifts that have been evaluated in the postclosure performance assessment.

4.2.4.4.1 Structural Steel

Criteria—Structural steel for the invert structure in emplacement drifts and transfer dock structures shall conform to ASTM A 588/A 588M-03 [DIRS 165008], corrosion resistant, high-strength, low-alloy steel.

All other applications including platforms, bulkhead plates, stiffeners, and miscellaneous steel shall conform to ASTM A 36/A 36M-04, *Standard Specification for Carbon Structural Steel* [DIRS 169609]; ASTM A 992/A 992M-02, *Standard Specification for Structural Steel Shapes* [DIRS 158926]; or ASTM A 500-01a, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes* [DIRS 158930] carbon steel, with a minimum yield stress of 36 ksi. Higher strength and/or corrosion resistant materials may be used if required by the design.

Structural bolts shall conform to ASTM A325-02 [DIRS 158936] or ASTM A490-02 [DIRS 158937]. Bolts for the platform and stairs may conform to ASTM A307-00 [DIRS 154217]. Structural connections shall be bearing type connections, except where slip critical connections are essential. Anchor bolts shall conform as a minimum to ASTM A 307-00 [DIRS 154217] with a minimum yield of 36 ksi.

Welding electrodes shall conform to Table 3.1 of the AWS D1.1/D1.1M:2002 [DIRS 157203].

Technical Rationale—Structural steel in emplacement drifts is subjected to a corrosive environment; therefore, corrosion resistant material is recommended. Outside emplacement drifts industry standard materials are used.

4.2.4.4.2 Concrete and Reinforcing Steel

Criteria—Reinforced concrete structures are not used in the emplacement drifts. Concrete structures used in nonemplacement areas shall conform to the following material properties:

- Concrete compressive strength (f'_c), based on 28 days strength, shall be 4,000-psi minimum.

- Reinforcing steel shall be deformed bars conforming to ASTM A 615/A 615M-01b [DIRS 158033] or ASTM A 706/A 706 M-01 [DIRS 159360], Grade 60, with a minimum yield stress of 60,000 psi.

- Welded wire fabric shall conform to ASTM A 185-01 [DIRS 157994].

Technical Rationale—Concrete and reinforcing materials are selected to conform with industry standards.

4.2.4.4.3 Nonshrink Grout

Criteria—Nonshrink grout, where used, shall be based on type K Portland (ASTM C 150-02, *Standard Specification for Portland Cement* [DIRS 158105]); cement silica fume (ASTM C 1240-01, *Standard Specification for Use of Silica Fume as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout* [DIRS 158843]); super plasticizer; and admixtures (ASTM C 494/C 494M-99a, *Standard Specification for Chemical Admixtures for Concrete* [DIRS 154218]).

Technical Rationale—Grout mix is selected to minimize the affects of shrinkage and to improve flowability.

4.2.4.4.4 Ballast

Criteria—Crushed tuff generated from the tunnel boring machine excavations shall be evaluated for its suitability for use as ballast material for the emplacement drift invert. Technical specification shall then be developed that describes the requirements for the ballast material, placement, and compaction.

Technical Rationale—Ballast material will be selected based on its suitability for use in the tunnel.

4.2.4.5 Environment and Corrosion Effects

The emplacement and nonemplacement areas of the subsurface facility are subject to the normal air temperature ranges listed in Table 4.2.4-5 and to the following operating environment during the preclosure period:

- Relative Humidity—Low 3%, High 10%

- Ionizing Radiation—Low levels of beta particles, neutron, and high and low energy photons (gamma and x-rays)

- Biological—Minimal effects.

The emplacement drifts and downstream airway openings and structures are also subject to off-normal peak temperatures not to be exceeded for a predetermined duration, as listed in Section 4.8.3.1.1.

High temperatures in the emplacement drifts and downstream airway openings are caused by heat output generated by the waste packages.

Continuous ventilation during the preclosure period will moderate the relative humidity. The relative humidity in the emplacement drifts is based on *ANSYS Calculations in Support of Natural Ventilation Parametric Study for SR* (BSC 2001 [DIRS 155246], Figure 6-5, p. 62).

In the repository environment, many different microbes could grow and provide potential chemical processes that may affect bulk chemistry within the emplacement drift construction materials. However, during the preclosure period, the emplacement drifts are expected to be dry and low in relative humidity (about 10 percent or lower). The potential microbiological affects on steel material will be insignificant under this environment.

4.2.4.5.1 Environmental Effects

Criteria—Materials used in the emplacement drifts shall be evaluated with regards to the expected operating environment.

Technical Rational—Materials used in the design must meet design requirements in the expected operating environment.

4.2.4.5.2 Corrosion Effects

Criteria—A corrosion allowance for structural steel members shall be determined to allow for material degradation due to potential corrosion during the preclosure period in the subsurface facility.

Technical Rationale—Factors that have a potential to effect corrosion in emplacement drifts are identified in *Corrosion Evaluation of Steel Ground Support Components* (BSC 2003 [DIRS 162448]); hence, a corrosion allowance is provided.

4.2.4.6 Design Loads

SSCs shall be designed for the following loads.

4.2.4.6.1 Dead Loads (D)

Criteria—Dead loads shall be those loads that remain permanently in place and include the weight of framing, permanent equipment, and all attachments.

Technical Rationale—Industry standard practice.

4.2.4.6.2 Live Loads (L and L_o)

Criteria—Live loads (L) shall be those loads that are superimposed by the use and occupancy of the building or structure. Minimum live loads used for the design shall not be less than the following:

- Platforms, walkways, and stairs
  - Uniform live load 100 psf
  - Concentrated load 1,000 lbs.

  These loads are concurrent. Concentrated load shall be applied to maximize moment and shear.

Construction loads for the steel invert structure	500 psf
Minimum traffic load near shafts	H20 truck loading (AASHTO 2002 [DIRS 164304])
Minimum surcharge load	300 psf
Minimum laydown load near shafts	250 psf.

Live load (L_o) is defined as the live load expected to be present during an earthquake event. L_o equal to 25 percent of the minimum uniform design live loads, as specified previously, may be used.

Technical Rationale—Recommended live loads and construction loads are based on the industry standard and construction experiences.

4.2.4.6.3 Seismic Loads (E)

Criteria—Seismic loads for the underground SSCs shall be computed based on the seismic ground motion corresponding to 2,000-year return period, located at the repository elevation (Point B, Figure 6.1.3-1).

Preliminary Design—The methodology for computing seismic loads for the subsurface SSCs during the preliminary design phase shall be based on the equivalent static load method in accordance with the requirements of NUREG-0800 (NRC 1989 [DIRS 165111], Section 3.7.2). To obtain an equivalent static load in the horizontal and vertical directions, a factor of 1.5 is applied to the respective peak ground acceleration of the applicable response spectra, using appropriate damping values for the structure or component. Damping values as expressed in terms of the percent of critical damping and are shown in Table 4.2.4-4.

Detailed Design—During the detailed design phase used for construction and operations, loads shall be computed using natural frequencies of the supporting structures and the corresponding accelerations from the applicable response spectra. Uncertainties in the design parameters are considered and design margins incorporated. For structural components anchored to the drift walls and shown to be rigid, a zero period acceleration of the applicable response spectra may be used.

Alternatively, a dynamic analysis (e.g., time history method or response spectrum method) shall be used when structural components are determined to have an amplified response. Analysis shall account for effects of soil-structure interaction, where applicable. Torsional effects shall be included.

For calculation of the total seismic response, the individual responses from the three orthogonal components of earthquake motion shall be combined by taking either the square root of the sum of the squares (SRSS) of the maximum codirectional responses caused by each of the three components of earthquake motion (SRSS method in NUREG-0800 [NRC 1989 [DIRS 165111], Section 3.7.2]) or the component factor method (1.0+0.4+0.4) (ASCE 4-98 [DIRS 159618]). Each component factor represents codirectional responses from the two horizontal and vertical seismic motions.

Table 4.2.4-4. Damping Values

Structure or Component	Damping Value
Welded Steel Structures	4 percent
Bolted Steel Structures	7 percent
Reinforced Concrete Structures	7 percent

In addition, structures connected to the subsurface emplacement drift walls will undergo structural deformations that are imposed and controlled by the tunnel deformations caused by the seismic ground motion. Such actions are termed deformation-controlled, which shall be evaluated and accounted for in the design.

Seismic loads for the non-SC subsurface facility SSCs that are located at the surface above the repository elevation shall be computed in accordance with the requirement of the IBC (ICC 2000 [DIRS 159179]).

Technical Rationale—Seismic loads for the surface SSCs are based on the IBC (ICC 2000 [DIRS 159179]). Seismic loads for the underground structures are based on NUREG-0800 (NRC 1989 [DIRS 165111], Section 3.7.2) because the IBC (ICC 2000 [DIRS 159179]) does not provide guideline for computing seismic loads for underground structures.

4.2.4.6.4 Gantry Crane Loads (CL)

Criteria—Gantry crane supplier's information shall be used for the crane weight, wheel loads, and lifted loads for the final design of crane rails and supporting structural steel beams. Impact allowances shall be in accordance with AISC (1997 [DIRS 107063], Sections A4.2 and A4.3). The weight of the loaded crane shall be considered simultaneously with the seismic loads. The horizontal and vertical inertia forces shall be obtained by multiplying the weight of the crane by the appropriate accelerations.

Technical Rationale—Crane load guidelines are provided according to AISC (1997 [DIRS 107063]).

4.2.4.6.5 Waste Package Loads (WP)

Criteria—For steel invert design, the maximum weight of the waste packages shall be used. The maximum weight of the pallet supporting the waste package is provided by the Waste Package and Components group.

Technical Rationale—Maximum waste package and supporting pallet loads are needed for the design of the steel invert. The loads are provided by the Waste Package and Components group.

4.2.4.6.6 Drip Shield Loads (DS)

Criteria—Drip shields in the emplacement drifts are planned to protect the waste packages from the rock fall and water intrusion during the postclosure period of 10,000 years. Drip shields shall be installed after the completion of emplacement of all waste packages and prior to closure. Drip shield loads shall be provided by the Waste Package and Components group. No backfill is anticipated for the postclosure period. However, the backfill option shall not be precluded.

Technical Rationale—Drip shield loads are needed for the design of the steel invert. It is provided by the Waste Package and Components group.

4.2.4.6.7 Ventilation Pressure Loads (P)

Criteria—Isolation barriers, steel bulkheads, and ventilation doors shall be designed for the ventilation differential pressure load, in addition to the dead and seismic loads. Maximum ventilation differential pressure shall be equivalent to the potential maximum primary fan pressure transmitted when the barrier and turnout bulkheads are closed.

Intake and exhaust shaft collar and ventilation sweep shall be designed for the maximum internal air pressure.

Technical Rationale—Maximum ventilation differential pressure is needed to design the barriers, bulkheads, and doors and shall be provided by the Subsurface Ventilation group. Maximum internal air pressure needed to design shaft collars and vent sweeps is provided by the Subsurface Ventilation group.

4.2.4.6.8 Temperature Loads (T)

Criteria—The design of SSCs shall include the effects of variations in temperatures. Air temperatures in emplacement and nonemplacement areas of the subsurface facility are not expected to fall outside the normal operating ranges listed in Table 4.2.4-5. Design temperatures for structural components shall consider these normal air temperature ranges in addition to deviations (temperature spikes for a given duration) that might occur during off-normal events affecting subsurface ventilation mechanical equipment or ventilation underground airways (Section 4.8.3.1.2).

Table 4.2.4-5. Normal Range of Air Temperatures for Subsurface Facility

Subsurface Facility Areas	Normal Air Temperature Range, °C	Comment
Access Mains and Turnouts[c]	13-32	Habitable conditions
Fully loaded emplacement drifts[a] (Uninhabitable)	23–74	In-drift air temperatures vary per these parameters: location in drift (low values near drift entrance); emplacement drift length; and years of ventilation. NOTES: (a) 23°C is the emplacement drift inlet design temperature; (b) in-drift air temperatures are maintained below 50°C when emplacement equipment is operating.
Exhaust mains, shaft access drifts, and shafts[a] (Uninhabitable)	42–74	Temperatures in these areas vary with extent of emplacement in a given area or panel, and years of ventilation.
Exhaust fans[b]	32–64	These temperatures reflect a 10-degree cooling for the vertical ascent.

Sources: [a] DTN: MO0307MWDAC8MV.000 [DIRS 165395]

[b] Hartman et al. 1997 [DIRS 101877], Equation 16.2

[c] DTN: GS030808312231.004 [DIRS 166735], SEP Table S0332701

Technical Rationale—Design peak wall temperatures in emplacement drifts and downstream airway openings are provided in Section 4.8.3.1.2 and are based on temperature limits that will preserve structural integrity of ground support and structural components for off-normal event conditions not to exceed a predetermined duration.

4.2.4.7 Load Combinations and Stress Allowables

Notations:

D = Dead loads
L = Live loads
E = Seismic loads
CL = Gantry crane loads
WP = Waste package load plus emplacement pallet load
DS = Drip shield loads
P = Ventilation pressure differential loads
T = Temperature loads.

4.2.4.7.1 Steel Structures

Criteria—Invert steel structures in the emplacement drifts are designated as non-SC SSC and shall be designed in accordance with the following load combinations, as applicable:

$$S = D + CL + L + P$$
$$S = D + CL + L + P + T$$
$$S = D + WP + DS + L + P$$

$$S = D + WP + DS + L + P + T$$
$$S = D + CL + L + P + E$$
$$S = D + CL + L + P + T + E$$
$$S = D + WP + DS + L + P + E$$
$$S = D + WP + DS + L + P + T + E$$

S = Allowable stress as permitted by the American Institute of Steel Construction (AISC) ASD method (AISC 1997 [DIRS 107063]).

NOTE: Allowable stresses may be increased by 33 percent when seismic load is present in the above load combinations.

Other steel structures and components that are in the subsurface area and designated as non-SC SSCs shall be designed in accordance with the following load combinations of the IBC (ICC 2000 [DIRS 159179], Section 1605.3.2) and conform to the requirements of the AISC ASD method (AISC 1997 [DIRS 107063]):

$$S = D + L$$
$$S = D + L + P + T$$
$$S = D + L + 0.7E$$
$$S = D + L + P + T + 0.7E$$
$$S = 0.9D + 0.7E$$

S = Allowable stress as permitted by the AISC ASD method.

Technical Rationale—Steel structures that are designated as non-SC SSCs are based on the AISC ASD method and in conformance with the industry practice.

4.2.4.7.2 Concrete Structures

Criteria—Concrete structures are not expected to be used in the emplacement drifts. Concrete structures where used in the nonemplacement areas are designated as non-SC SSCs and shall be designed in accordance with the following load combinations, conforming to the requirements of the IBC (ICC 2000 [DIRS 159179]):

$$U = 1.4D$$
$$U = 1.2D + 1.6L$$
$$U = 1.2D + 1.2T + 1.6L$$
$$U = 1.2D + 1.0L + 1.0E$$
$$U = 1.2D + 1.2T + 1.0L + 1.0E$$
$$U = 0.9D + 1.0E$$

U = Required strength per the IBC (ICC 2000 [DIRS 159179]).

NOTE: Above load combinations are not applicable to concrete shaft collar design.

Technical Rationale—The design load combinations listed for the concrete structures that may be used in the nonemplacement area are based on the IBC. These structures are classified as non-SC SSCs and it is an industry practice to design them in accordance with the IBC (ICC 2000 [DIRS 159179]).

4.2.4.7.3 Foundation Design

Criteria—Foundation design for the SSCs designated as ITS or ITWI shall be in accordance with the requirements of NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.8.5). Foundation design for the non-SC SSCs shall be in accordance with the requirements of the IBC (ICC 2000 [DIRS 159179], Chapter 18).

Technical Rationale—Foundations that are ITS or ITWI are required to be designed in accordance with the requirements of NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.8.5). Other foundations are designed to the IBC (ICC 2000 [DIRS 159179]).

4.2.4.7.4 Surface Structures that are Part of Subsurface Facilities

Criteria—Surface structures that are part of subsurface facilities are categorized as non-SC SSCs and shall be designed in accordance with applicable sections of Section 4.2.2.5.

Technical Rationale—Required design criteria for conventional structures located at the surface level are provided in Section 4.2.2.5.

4.2.4.8 Anchors

4.2.4.8.1 Rock Anchors

Criteria—Rock anchors shall conform to applicable criteria in Section 4.5. In addition, the Subsurface Geotechnical group shall develop a design table for the bearing type bolts with the allowable shear capacity. Specifications shall include installation and testing requirements.

Technical Rationale—Section 4.5 is developed by the Subsurface Geotechnical group. The rock anchors discussed in this section will be of similar materials, design, and installation as the rock bolts used for ground support specified in Section 4.5. The criteria to conform to the rock bolts specified in Section 4.5 are to prevent duplication of effort between design sections and to ensure uniformity of materials, installation, and testing. Shear is rarely a controlling factor in geotechnical design, but it may control in civil design.

4.2.4.8.2 Concrete Expansion Anchors

Criteria—Concrete expansion anchors shall be designed and installed in accordance with manufacturer recommendations.

Technical Rationale—It is industry practice to design and install expansion anchors in accordance with manufacturer recommendations.

4.2.4.9 Permanent Subsurface Railway Design

Criteria—The permanent subsurface facility railway design shall be in accordance with the American Railway Engineering and Maintenance-of-Way Association (AREMA 2002 [DIRS 171657]).

- Track layout shall conform to the subsurface opening layout and transportation envelope.
- The invert structures shall be designed for a Cooper E-80 loading (AREMA 2002 [DIRS 171657]).
- Rail to be used shall be new and in accordance with AREMA (2002 [DIRS 171657]).
- Track directly fixed to concrete slabs (concrete slab track) shall comply with AREMA (2002 [DIRS 171657]).
- Track shall not be super-elevated.
- Emplacement drift gantry rail shall comply with CMAA 70-2000 [DIRS 153997].

Technical Rationale—The bases for railway facilities design are the criteria in AREMA (2002 [DIRS 171657]) and established engineering practice. Railway structures are designed for Cooper E-80 loading as consensus recommendations for heavy haul applications.

4.3 ELECTRICAL DESIGN CRITERIA

4.3.1 General Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Electrical[b]	ANSI C84.1-1995, ANSI/ICEA S-80-576-2002, ANSI/ICEA S-87-640-1999, ANSI/IEEE Std 260.1-1993, ANSI/IEEE Std 344-1987 (Reaffirmed 1993), ANSI/IEEE Std 944-1986, ANSI/IES-RP-7-1991, ANSI/IESNA RP-1-1993, ANSI/IESNA RP-22-96-1996, ANSI/IESNA RP-8-00, ANSI/NEMA 250-1997, ANSI/NEMA WC 55-1992, ANSI/UL 467-1998, ICEA S-83-596-2001, IEEE Std 1050-1996, IEEE Std 1100-1999, IEEE Std 1115-2000, IEEE Std 112-1996, IEEE Std 1184-1994, IEEE Std 1188-1996, IEEE Std 1189-1996, IEEE Std 1202-1991, IEEE Std 1205-2000, IEEE Std 141-1993, IEEE Std 142-1991, IEEE Std 241-1990, IEEE Std 242-2001, IEEE Std 383™-2003, IEEE Std 399-1997, IEEE Std 446-1995, IEEE Std 484™-2002, IEEE Std 485-1997, IEEE Std 515™ 2004, IEEE Std 519-1992, IEEE Std 524™-2003, IEEE Std 665-1995, IEEE Std 751-1991, IEEE Std 80-2000, IEEE Std 81-1983, IEEE Std 835-1994, IEEE Std 946-1992, IEEE Std C37.110-1996, IEEE Std C37.20.1-2002, IEEE Std C57.12.23™-2002, IEEE Std C62.23-1995, NACE Standard RP0169-2002, NACE Standard RP0572-2001, NEMA ICS 7-2000, NEMA MG 1-1998, NEMA PB 1-1990, NEMA PB 2-2001, NEMA PE 1-2003, NEMA SG 5-1995, NEMA SG 6-2000, NEMA TR 1-1993, NEMA WC 2-1991, NEMA WC 50-1976 (R 1982, 1988), NEMA WC 51-2003, NEMA WC 57-1995, NEMA WC 58-1997, NEMA WC 7-1988, NEMA WC 70/ICEA S-95-658-1999, NEMA WC 71-1999, NEMA WC 74-2000, NEMA WC 8-1998, NFPA 101®-2003, NFPA 110-2005, NFPA 70-2004, NFPA 780-2004, NFPA 801-2003, Rea 2000, UL 67-2003, UL 508-2003, UL 96A-2001, UL 1581-2003
		Regulatory Guide 8.8
		10 CFR 50.49, 29 CFR Part 1910, 29 CFR Part 1926
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022). Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This regulatory guide is used for the development of design products for the preliminary design. The level of conformance with regulatory positions in this regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide. Addressing this regulatory guide supports compliance with requirements for the electrical power system.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-020.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.3.1.1 System Design

4.3.1.1.1

Criteria—The system design shall provide a spare margin to accommodate future load growth for transformers, switchgear, and raceway. The spare margin will be determined in the detail design phase of the project.

Technical Rationale—This criterion is needed to ensure that the electrical system is designed with sufficient margin for the future. The design margin is applied in addition to the system loads defined during the final design.

4.3.1.1.2

Criteria—The system shall regulate the utilization voltage to ±10 percent except for voltages 480V and below, which shall have maximums +5 percent and minimums of -10 percent. Maximum momentary bus voltage dip on the 4.16 kV buses during starting of a 4 kV motor is -20 percent. Motor terminal voltage range under steady-state operating condition is ±10 percent of the motor-rated terminal voltage. Minimum motor terminal voltage while starting with all other motors running is 80 percent of the motor-rated terminal voltage.

Technical Rationale—This criterion is needed to define the utilization voltage limits for the end item equipment. This voltage drop limit is for normal operations because a momentary voltage drop will occur for the starting of large motors. By National Electrical Manufacturers Association (NEMA) standards, the electrical equipment is made to perform well within ±10 percent of rated voltage. For voltages of 600 volts and below, NFPA 70-2004 [DIRS 172711] describes that the voltage drop on feeder circuits (between MCC and panelboard) and branch circuits (between panelboard and load) combined should not exceed ±5 percent.

4.3.1.1.3

Criteria—The YMP power systems shall be divided into normal, standby, and emergency power systems. The uninterruptible and direct current (DC) power sources shall be included for uninterruptible power as well as protective relaying and control functions.

Technical Rationale—This criterion is required to define the power distribution systems.

4.3.1.1.4

Criteria—The facility normal power supply voltages shall be:

- 12.47 kV, 60 Hz, 3-phase, 3-wire, low resistance grounded neutral
- 4.16 kV, 60 Hz, 3-phase, 3-wire, low resistance grounded neutral
- 480V, 60 Hz, 3-phase, 3-wire, solidly grounded neutral
- 480/277 V, 60 Hz, 3-phase, 4-wire, solidly grounded neutral
- 208/120 V, 60 Hz, 3-phase, 4-wire, solidly grounded neutral
- 240/120 V, 60 Hz, 1-phase, 3-wire, solidly grounded neutral

The DC battery system voltage shall be 125 V.

Technical Rationale—This criterion is required to define the facility application voltages in compliance with IEEE Std 141-1993 [DIRS 122242]. These voltages are most commonly used in the industry in the United States for medium- and low-voltage systems. The electrical equipment are most readily available in these voltages. Their performances have long been proven. The medium voltage, 12.47 kV, is currently used in the existing system at the site; therefore, it is selected over the 13.8 kV system for service continuity.

4.3.1.1.5

Criteria—The DC power system shall be used for protective relaying and medium-voltage switchgear control, as needed.

Technical Rationale—This criterion is required to define the facility medium-voltage switchgear control voltage for the service continuity capability. The DC power will be available even in facility blackout. Therefore, the critical circuit breaker control capability is secured.

4.3.1.1.6

Criteria—All facility electrical loads shall be designated as either group A or B. Each group receives power from one of two main switchgears, A or B. The loads shall be distributed as much as possible to achieve balance between the two main switchgears.

Technical Rationale—This criterion is required to define the power distribution system structure. This can simplify the system design, system control, avoid a common mode failure, or minimize the effects of failure of one load group. Division of the loads can also facilitate maintenance and increase availability of the facility loads.

4.3.1.1.7

Criteria—All electrical equipment, raceways, and cables of the YMP facility shall be given unique identification numbers, except for lightning protection, cathodic protection, and grounding systems.

Technical Rationale—This criterion is required to facilitate the safety, correct installation and operation, and easiness of inventory and maintenance.

4.3.1.1.8

Criteria—Transformers shall be liquid-filled for outdoor service and dry-type for indoor and subsurface service.

Technical Rationale—This criterion is required for increasing the outdoor transformer efficiency and minimizing the potential fire hazards, which can be caused by indoor transformers.

4.3.1.1.9

Criteria—The transformers for outdoor installation shall be 12.47 kV to 4.16 kV, 12.47 kV to 480/277 V, 4.16 kV to 480/277 V, and 480 V to 208/120 V, 3-phase, 60 Hz, with no-load manually operated taps. The primary side shall be delta connected; the secondary side shall be wye connected; and the neutral resistance grounded for 4.16 kV secondary and solid grounded for 480 V secondary.

Technical Rationale—This criterion is required to standardize design for reliable operation. The transformers with these voltages are most commonly used in the industry. The neutral resistance grounding in the medium-voltage system will minimize the fault current for human safety. The solid neutral grounding for the low-voltage system will facilitate quick clearing of fault. The delta-wye connection will minimize grounding fault effects and minimize harmonics in the system.

4.3.1.1.10

Criteria—The medium-voltage switchgears shall be rated at 12.47 kV or 4.16 kV, 3-phase, 60 Hz. The switchgears shall be rated to withstand the maximum short-circuit current available in the system.

Technical Rationale—This criterion is required to define the system operation voltages and to standardize design. The maximum short-circuit current withstanding capability is required for protection of personnel safety, equipment and system protection.

4.3.1.1.11

Criteria—Lighting and instrumentation transformers shall be dry type (except outdoor application). The primary shall be delta connected and secondary shall be wye connected and neutral solidly grounded (480/277 V or 208/120 V).

The single phase lighting transformer of 480-240/120 V can also be used as required.

Technical Rationale—This criterion is required to standardize design for a reliable and safe operation. It will minimize fire hazards by not using an oil-filled transformer for indoor application and minimize harmonics in the system.

4.3.1.1.12

Criteria—The 480 V load center (switchgear) shall be used to provide power to the downstream motor control centers and motors larger than 150 hp up to 250 hp, and static loads up to 400 kW.

Technical Rationale—This criterion is required to define the role of the 480 V load center and safe operation of medium size 480V motors and other static loads. This is the common accepted industry practice. This practice will minimize the stress in electrical equipment. This will enable equipment a long-term operation.

4.3.1.1.13

Criteria—The 480 V motor control center shall be used to provide alternating current (AC) power to induction motors and other loads rated 150 hp or below, but above 1/3 hp, and miscellaneous branch circuits. Static (resistive) loads up to 240 kW can be served from motor control centers.

Technical Rationale—This criterion is required to define the role of the 480V motor control center and for reliable and safe operation of low integral or fractional size motors and other static loads. This is the common accepted industry practice. This practice will facilitate easy installation and easy replacement of motors or static loads.

4.3.1.1.14

Criteria—In general, alternating current (AC) motors shall be squirrel-cage, induction type, and suitable for operation from the following supplies listed in Table 4.3.1-1.

Table 4.3.1-1. AC Motor Supplies

Motor Size	Utilization Voltage	System Supply
1/3 hp and smaller	115V	120V, 1-phase, 60 Hz
1/2 hp to 250 hp	460V	480V, 3-phase, 60 Hz
251 hp to 4,000 hp	4 kV	4.16 kV, 3-phase, 60 Hz
Adjustable speed, reversing and two-speed motors	460V	480V, 3-phase, 60 Hz

Technical Rationale—This criterion is required to define the motor application voltages for reliable and safe operation. This is commonly accepted industry practice and listed in IEEE Std 141-1993 [DIRS 122242] and ANSI Std C84.1-1995 [DIRS 126007].

4.3.1.1.15

Criteria—The motors used for outdoor installation or in the hazard location shall be either totally enclosed fan-cooled, totally enclosed non-ventilated, or weather-protected and Type II.

Technical Rationale—This criterion is required to ensure that the motor is protected from weather or chemical hazards.

4.3.1.1.16

Criteria—The 4 kV motors shall be designed to accelerate the load with 80 percent rated voltage at the motor terminals during the motor starting period.

Technical Rationale—This criterion is required to ensure that the motor is able to start and accelerate its load, even at a point that the electric power supply system is at its designed minimum value.

4.3.1.1.17

Criteria—Motors shall be provided with single phase or three phase space heaters to keep the motor winding and internal parts dry when the motor is not running.

Technical Rationale—This is a common industry practice to keep moisture from degrading or damaging the motor winding and internal parts.

4.3.1.1.18

Criteria—The voltage rating of the motor space heaters shall be rated 240 volts of alternating current (VAC) for heaters to be powered from the 120 VAC, single phase source, and 575 VAC for heaters to be powered from the 480 VAC, single phase or three phase. The space heaters for motors shall be energized automatically when the motor is idle. The space heaters for motor operated valves shall be energized continuously.

Technical Rationale—This is a common industry practice that provides the space heater extended service life and still does its intended function.

4.3.1.1.19

Criteria—Variable speed drive shall be used where it is required to control speed of the driven mechanical equipment.

Technical Rationale—This criterion is required because some mechanical equipment requires variable speeds for operation, or requires large torque to start rotation.

4.3.1.1.20

Criteria—The DC battery systems shall be 125 volts of direct current (VDC) nominal voltage. The battery systems shall be designed for a long life and with low maintenance requirements per NFPA 70-2004 [DIRS 172711]. The DC power system shall be backed-up by diesel generators.

Technical Rationale—This criterion is required to define the DC system voltage. The voltage is most commonly used in the industry. The performance and reliability are superior. Lead acid batteries with long life and low maintenance type shall be required. The minimum battery discharge time is required to assure a continuous power supply during a loss of normal power. This is critical for a safe facility operation and power failure by providing sufficient backup power.

4.3.1.1.21

Criteria—The 125 VDC equipment shall be designed to operate between 140 VDC and 105 VDC range.

Technical Rationale—The standard battery and battery charger system voltages range from 140 VDC when the battery is being charged to a minimum of 105 VDC. This is a common industry requirement.

4.3.1.1.22

Criteria—The 125 VDC systems shall be ungrounded with a ground detection system on the positive and negative legs. Other alarms shall include battery breaker position open alarm, battery charger output breaker position open alarm, battery charger AC undervoltage alarm, battery charger DC overvoltage alarm, and battery charger DC undervoltage alarm.

Technical Rationale—This is a common industry practice to enable the DC systems to satisfy the reliability and availability requirements expected of the system.

4.3.1.1.23

Criteria—Uninterruptible power supplies (UPS) shall be provided to supply the critical power of acceptable quality, without delay or transient during a power interruption, to important monitoring and control loads that cannot tolerate a power interruption. Important computer systems shall also be supplied with UPS. Furthermore, the waste package closure system will also be supplied by an UPS so that a controlled shutdown of the welding process can be performed upon loss of power.

Technical Rationale—This criterion is required per IEEE Std 446-1995, *IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications* [DIRS 125763]. This system is also of critical importance to the emergency system.

4.3.1.1.24

Criteria—The UPS systems for facility control and instrumentation applications shall be supplied by 480V AC power and the output shall be 208/120V, 3-phase, 60 Hz. The UPS battery banks shall be sized to provide UPS power for the duty cycle required by the load it feeds.

Technical Rationale—This criterion is required to define the UPS system voltage. The selected voltage is most commonly used in the industry. The performance and reliability are superior. The minimum continuous UPS operating time is an industry standard and allows adequate time for the diesel generators to supply power to UPS backed equipment. The requirement of providing uninterruptible power is also indicated in NFPA 70-2004 [DIRS 172711].

4.3.1.1.25

Criteria—The standby diesel generators shall be rated 12.47 kV, and the emergency diesel generators shall be rated 4.16 kV, 3-phase, and 60 Hz, wye connected. Upon loss of voltage on their buses, the standby diesel generator and the emergency diesel generators shall be automatically started.

Technical Rationale—This criterion is required for the optimum system design. The amount of standby power required during loss of offsite power is expected to be several megawatts. This amount will require a set of 12.47 kV generators for support. Because the scope of emergency equipment or system will be kept to a minimum, the emergency diesel generator can be rated at a lower voltage. The start and ready for loading time for the standby and the emergency diesel generator is based on NFPA 70-2004 [DIRS 172711].

4.3.1.2 Lighting System

4.3.1.2.1

Criteria—Lighting systems shall be designed in accordance with *IESNA Lighting Handbook, Reference and Application* (Rea 2000 [DIRS 165131]); ANSI\IESNA RP-22-96-1996, *IESNA Recommended Practice for Tunnel Lighting* [DIRS 166693]; ANSI/IESNA RP-1-1993, *American National Standard Practice for Office Lighting* [DIRS 122142]; ANSI/IES-RP-7-1991, *American National Standard Practice for Industrial Lighting* [DIRS 122135]; ANSI/IESNA RP-8-00, *Standard Practice for Roadway Lighting* [DIRS 173093] and NFPA 70-2004 [DIRS 172711]. It will consist of the normal, essential, and emergency lighting systems. Normal lighting shall be provided in areas where sudden loss of light does not affect safety or production. The essential lighting shall be provided in areas where sudden loss of light does have an affect on production and safety to personnel. The emergency lighting shall be provided in areas where manual operations, sustained system operations, and exits from the facilities are required during postulated emergencies. The emergency lighting shall include egress, safeguard, and security lighting.

Technical Rationale—This criterion is required to ensure adequate illumination for all areas in the facility and operations during all modes of facilities operations.

4.3.1.2.2

Criteria—As a minimum, the lighting system shall provide illumination levels per the requirements of *IESNA Lighting Handbook, Reference and Application* (Rea 2000 [DIRS 165131]), ANSI/IESNA RP-1-1993 [DIRS 122142], ANSI/IES-RP-7-1991 [DIRS 122135], ANSI/IESNA RP-8-00 [DIRS 173093], ANSI/IESNA Std RP-22-96-1996 [DIRS 166693], and NFPA 70-2004 [DIRS 172711].

Technical Rationale—This criterion is required to define the lighting requirements for the surface and subsurface facilities to support all modes of operations with adequate levels of illumination.

4.3.1.3 Cable

4.3.1.3.1

Criteria—The 15 kV and 5 kV power cables shall be shielded and shall be either a single conductor or a triplexed Class B stranded copper conductor, with a 133 percent insulation level, rated for continuous operation at 90°C, 130°C for emergency overload operation, and 250°C for short circuit conditions in accordance with applicable Insulated Cable Engineers Association (ICEA) standards (NEMA WC 8-1988 [DIRS 158601]; NEMA WC 58-1997 [DIRS 158602]; NEMA WC 7-1988 [DIRS 173594]; ANSI/NEMA WC 55-1992 [DIRS 173595]; ANSI/ICEA S-80-576-2002 [DIRS 173596]; ICEA S-83-596-2001 [DIRS 173597]; ANSI/ICEA S-87-640-1999 [DIRS 173598]; NEMA WC 2-1991 [DIRS 173599]; NEMA WC 50-1976 (R 1982, 1988) [DIRS 173600]; NEMA WC 51-2003 [DIRS 173601]; NEMA WC 57-1995 [DIRS 173602]; NEMA WC 70/ICEA S-95-658-1999 [DIRS 173603]; NEMA WC 71-1999 [DIRS 173604]; NEMA WC 74-2000 [DIRS 173605]).

Technical Rationale—This criterion is required to ensure the quality of cables to be satisfactory for normal and emergency applications.

4.3.1.3.2

Criteria—The 480 V power, 208/120 V lighting, 480 V motor feeder and 120 V control cables shall be single conductors or multi-conductors, copper, rated 600 V and 75°C. The conductor shall be hard-drawn or stranded copper. All power and control wiring shall be standard copper flame-retardant moisture and heat-resistant or heat-resistant thermoplastic insulated 75°C.

Technical Rationale—This criterion is required to ensure the quality of cables for YMP application. These are the most common and reliable cables that satisfy ICEA standards.

4.3.1.3.3

Criteria—Power cables of size #2/0 and larger shall be single conductor or triplexed. Cables for lighting circuits shall be single conductor, solid copper. Cable insulation and jacket material shall be resistant to heat, moisture, impact, radiation (where required), and ozone.

Technical Rationale—This criterion is required to ensure the quality of cables for YMP application. These are the most common and reliable cables that satisfy ICEA standards. Cables installed near radiation need to be protected for long-term performance.

4.3.1.3.4

Criteria—All lighting and receptacle panel branch circuits shall have a maximum of three circuits sharing a common neutral for single-phase loads. Where non-linear loads have been identified, the neutral shall be sized accordingly.

Technical Rationale—This criterion is required to limit the ground fault current passing a neutral conductor, for protection of integrity of the circuit. This is in accordance with NFPA 70-2004 [DIRS 172711], Article 250.

4.3.1.3.5

Criteria—Instrument cables shall be single-pair, triad-twisted and shielded, or multi-pair with shielded pair and overall shield and drain wire, unless supplied by the instrument vendor.

Technical Rationale—This criterion is required to shield off noise to the transmitted signal in the cable in order to prevent instrument malfunction due to the noises in the instrumentation cable.

4.3.1.3.6

Criteria—All instrument cable shall be fire-resistant per IEEE Std 1202-1991, *IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies* [DIRS 160800], and UL 1581-2003, *Reference Standard for Electrical Wires, Cables, and Flexible Cords* [DIRS 169577]. All instrument wiring shall be stranded. Fiber optic cable and field-bus shall be used for most data network, voice, and video communication. For cable with requirements for use in radiation environments such as transfer cells, aging effect of cables will be evaluated in accordance with Annex D of IEEE Std 1205-2000, *IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations* [DIRS 173725].

Technical Rationale—This criterion is required to ensure the satisfactory performance of cables with the state-of-the-art technologies. This will ensure integrity of instrumentation system function.

4.3.1.3.7

Criteria—Bulk cable insulation and jacket material shall be the low flammable type.

Technical Rationale—This criterion is required to protect cables from failure due to fire or heat.

4.3.1.3.8

Criteria—Control cables shall be multi-conductor and color coded in accordance with the ICEA standard method.

Technical Rationale—This criterion is required to comply with ICEA standards.

4.3.1.4 Grounding

4.3.1.4.1

Criteria—The system shall provide ground-fault detection and relaying to automatically de-energize any high-voltage system component that has developed a ground fault for circuits that are 1,000 volts or higher.

Technical Rationale—This criterion is needed to address ground-fault relaying and circuit de-energization. This criterion supports 29 CFR 1910.304(f)(7)(ii)(C) [DIRS 172709] and 29 CFR 1926.404(f)(11)(ii)(C) [DIRS 172710].

4.3.1.4.2

Criteria—A grounding system shall be furnished in the facility area to provide for personnel safety and to facilitate systems, structures, and equipment grounding.

Technical Rationale—This criterion is required to protect the safety of site and general public personnel in the area during a system fault (short circuit), lightning strike, or system voltage surge. It will also prevent equipment failure and mitigate damages to SSCs. This requirement is in compliance with IEEE Std 80-2000, *IEEE Guide for Safety in AC Substation Grounding* [DIRS 164256], and IEEE Std 142-1991, *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems* [DIRS 122245].

4.3.1.4.3

Criteria—The ground grid shall be designed per the requirements of IEEE Std 80-2000 [DIRS 164256] to limit touch and step potentials to safe values under the calculated ground fault conditions. The ground soil resistivity shall be measured per the requirements of IEEE Std 81-1983 [DIRS 102325]. Neutral grounding is designed in accordance with IEEE Std 665-1995, *IEEE Standard for Generating Station Grounding* [DIRS 173591].

Technical Rationale—This criterion is required for the safe and adequate design of the station grounding grid to protect the safety of site and general public personnel, systems, structures, buildings, and components during a system fault (short circuit), lightning strike, or system voltage surge.

4.3.1.4.4

Criteria—The main ground grid shall be made of bare copper no smaller than No. 4/0 American Wire Gauge (AWG), buried below the earth surface at no less than two and a half feet deep. The grounding rods shall be made of steel with copper clad and one inch diameter.

Technical Rationale—This criterion ensures that No. 4/0 AWG grounding conductor is adequate to carry the maximum available ground fault current safely and allow ground rods to be driven through the hard soil without damage. This rationale is based on the IEEE Std 80-2000 [DIRS 164256].

4.3.1.4.5

Criteria—Electrical equipment and steel, structures, and metal components in the building likely to become energized under abnormal conditions shall be effectively grounded to the site-grounding grid that connects to the main ground grid. Ground plates shall be located for multiple grounding runs from a single location. Columns and beams shall be connected to the site-grounding grid.

Technical Rationale—This criterion is required for the personnel safety and equipment protection. This rationale is based on the recommendations of IEEE Std 142-1991 [DIRS 122245] and requirements of NFPA 70-2004 [DIRS 172711].

4.3.1.4.6

Criteria—The grounding conductor for the instrument, digital systems, communication systems, and computer systems shall be kept separate and insulated until it connects to the main ground grid at one specific point (single point).

Technical Rationale—The single point ground system is used to eliminate circulation of ground current that causes common mode noise. The purpose of this criterion is to prevent instrument malfunctions due to noise on the line. This is the most commonly used system in an industrial environment. This rationale is based on the recommendations of IEEE Std 1050-1996, *Corrections to IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations* [DIRS 169773].

4.3.1.4.7

Criteria—Facility power system grounding shall be based on the following criteria:

- 12.47 kV system—This system shall be grounded through a neutral resistor to limit damaging ground fault current to a value adequate for relay operation (low resistance grounding).
- 4.16 kV system—This system shall be grounded through a neutral resistor to limit damaging ground fault current to a value adequate for relay operation (low resistance grounding).
- 480 V system—The neutral point for the system shall be solidly grounded to the ground grid.
- 480Y/277V system—The neutral point for the system shall be solidly grounded to the ground grid.
- 240Y/120V—The neutral point for the system shall be solidly grounded to the ground grid.
- 208Y/120V—The system neutral point shall be solidly grounded to the ground grid.
- 125-volts DC—Ungrounded.

Technical Rationale—This criterion is required for personnel safety and equipment protection. This rationale is based on the IEEE Std 142-1991 [DIRS 122245] and NFPA 70-2004 [DIRS 172711].

4.3.1.4.8

Criteria—All underground connections shall be made by a thermo-welding process or ANSI/UL 467-1998 [DIRS 159657] listed compression type connection approved for this application. Exposed connections and taps shall be made with pressure-type connectors.

Technical Rationale—This criterion is required because the thermo-weld connection underground is a better selection for prevention of corrosion. For exposed application, pressure type connection costs less and is easier to install or replace.

4.3.1.4.9

Criteria—Cable trays, supports, hangers, conduits, and fittings shall be effectively connected to the system ground network. Cable trays shall be grounded at both ends and individual tray sections shall be connected together for ground circuit continuity.

Technical Rationale—This criterion is required to protect personnel and electrical equipment from fault current. This criterion is also required to assure that at least one ground return path will be available for the ground fault current in case the ground return path is open at the other end.

4.3.1.4.10

Criteria—All motors shall be grounded through the grounding conductor enclosed in the power cable, or a ground wire run with the power circuit in conduit, to the ground bus in the motor control center and/or switchgear.

Technical Rationale—This criterion is required for personnel safety and equipment protection based on the procedures and recommendations of IEEE Std 142-1991 [DIRS 122245] and requirements of NFPA 70-2004 [DIRS 172711].

4.3.1.5 Lightning Protection

4.3.1.5.1

Criteria—All buildings, outdoor elevated structures, electrical equipment, and electrical power lines shall be protected with lightning arresters and surge capacitors.

Technical Rationale—This criterion is required to provide a designated path for the lighting current to dissipate to the ground and, thereby, protect life, equipment, buildings, and elevated outdoor structures against damages caused by lightning strikes.

4.3.1.5.2

Criteria—The lightning protection system shall be installed for all buildings and outdoor elevated structures in accordance with NFPA 780-2004, *Standard for the Installation of Lightning Protection Systems* [DIRS 173517], and UL 96A-2001 [DIRS 166768] standards. The protection system shall consist of air terminals bussed together and connected by at least two down conductors to the site grounding system. The surge protection circuit, to avoid equipment damage due to lightning discharge, is designed in accordance with IEEE Std C62.23-1995, *IEEE Application Guide for Surge Protection of Electric Generating Plants* [DIRS 173593].

Technical Rationale—This criterion is required for personnel safety and equipment protection based on the procedures and recommendations of NFPA 780-2004 [DIRS 173517] and UL 96A-2001 [DIRS 166768].

4.3.1.6 Cathodic Protection

4.3.1.6.1

Criteria—The cathodic protection system shall be designed per the requirement of NACE Standard RP0169-2002, *Standard Recommended Practice, Control of External Corrosion of Underground or Submerged Metallic Piping Systems* [DIRS 165132], and NACE Standard RP0572-2001, *Standard Recommended Practice, Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds* [DIRS 173097], for underground metallic piping systems and water/fuel oil tanks in contact with soil.

Technical Rationale—The cathodic protection system is provided per the requirements of NACE Standard RP0169-2002 [DIRS 165132] to mitigate underground metal corrosion and, thereby, increase the useful life of the existing underground metallic piping systems and water/fuel oil tanks in contact with the soil. This criterion is also required to prevent premature failures of underground metallic piping systems and water/fuel oil tanks in contact with the soil due to corrosion.

4.3.1.7 Heat Tracing

4.3.1.7.1

Criteria—Electrical heat tracing (freeze protection) shall be provided for liquid filled piping and instrument sensing lines that are subject to freezing per the requirements of the IEEE Std 515™-2004 [DIRS 169803]. The system shall be designed for the outdoor temperature range as defined in Section 6.1.1.5. The turn on and turn off temperature settings of the heat tracing system shall be based on the fluid properties and characteristics of the pipe insulation.

Technical Rationale—This criterion is required for the safe design of the heat tracing system and continuous facility normal operation of the liquid-filled piping and instrumentation sensing lines, especially in the freezing weather.

4.3.1.7.2

Criteria—The heat tracing cable supply voltage shall be 120V AC or 240V AC, 60 Hz. The incoming power shall be 480V AC, 3-phase, 60 Hz at the primary side of the heat tracing power distribution transformer.

Technical Rationale—The 120V AC and 240V AC are the most commonly accepted input voltage levels for the heat tracing system in the industry.

4.3.1.7.3

Criteria—The normal power shall be used to supply the heat tracing system. Backup onsite diesel generator power sources shall not be used to supply the heat tracing system unless it is required for some specific process to support important operations in the freezing weather.

Technical Rationale—This criterion will reduce load on the diesel generators during power outages and emergencies because loss of power to the heat tracing system generally will not affect operations or safety.

4.3.1.7.4

Criteria—In the heat tracing circuit, ground leakage protection shall be employed and be configured to provide local and remote indication of a ground fault.

Technical Rationale—This criterion is required for the safe operation of the system by detecting ground leaks early. The detection will enable prevention of larger faults. This rationale is based on the industry common practice.

4.3.1.7.5

Criteria—The heating cable shall be fire retardant, rated for continuous operation, and insulated to be capable of resisting the chemical operating environment.

Technical Rationale—This criterion is required for the design and operation of the heat tracing system.

4.3.1.8 Raceway Grouping

4.3.1.8.1

Criteria—For redundant loads that may be determined in detailed design, the cables and raceways shall be separated and routed from separate power systems via separate fire areas in accordance with the principles defined in NFPA 70-2004 [DIRS 172711].

Technical Rationale—For the selected emergency redundant loads, physical separation of emergency power cables are required to prevent simultaneous loss of selected emergency loads due to a fire in the same fire zone or other hazards such as flooding, icing, and vandalism.

4.3.1.9 Surface Raceway System

4.3.1.9.1

Criteria—Raceways are divided into two major classes: exposed and embedded systems. Exposed systems shall utilize cable tray or conduit arranged in a main distribution pattern branching out to serve individual equipment or devices. Embedded systems shall consist of conduit embedded in building floors (including trench), walls, and underground duct banks. The cable raceway for 600 volts nominal or less shall be designed per the requirements of NFPA 70-2004 [DIRS 172711], Chapter 3, and this document. The cable raceway for medium-voltage systems shall be designed by using applicable industry standards and this document.

Technical Rationale—This criterion is required for the mechanical protection of cables. This is the common practice in industry. In-floor trenches and cable pits can be used as required as special cases.

4.3.1.9.2

Criteria—Cables shall be routed in conduit or in cable trays to the individual equipment and devices. Underground duct banks shall be used between facilities and outlying structures.

Technical Rationale—This is the common practice in industry for the physical support and protection of cables. The duct bank prevents exposure of cable routing in the open areas of the surface facility.

4.3.1.9.3

Criteria—Power cable connections to loads in remote areas through rough mountainous surface shall be by overhead lines per IEEE Std 751-1991, *IEEE Trial-Use Design Guide for Wood Transmission Structures* [DIRS 170498]; IEEE Std 524™-2003, *IEEE Guide to the Installation of Overhead Transmission Line Conductors* [DIRS 169316]; and NFPA 70-2004 [DIRS 172711], Section 230.24.

Technical Rationale—This criterion is required for a cost effective and practical way to route cables to remote areas.

4.3.1.9.4

Criteria—A raceway designated for a single class of cables shall contain only cables of the same class. Cable trays containing low-voltage instrumentation cables with very low current control signals shall provide protection against spurious signal sources.

Technical Rationale—This criterion is required to prevent interference between different classes of cables. This is the common practice in industry. Protection of instrumentation cables is for prevention of equipment malfunctions due to noises mixed with a normal signal.

4.3.1.9.5

Criteria—Unless otherwise specified, only hot-dipped galvanized steel cable trays shall be used. Standard tray lengths and widths shall be specified, as necessary, to fit the design situation.

Technical Rationale—This criterion is required to standardize cable tray types. The hot-dipped galvanized steel cable tray will serve as the partial ground fault return path for protection of personnel and equipment. This is the common practice in industry.

4.3.1.9.6

Criteria—In general, for areas using stacked trays, the highest voltage cables shall occupy the highest position in the stack. Low-voltage power cables trays shall be located below medium-voltage power cables. Control cables shall be located below low-voltage power trays, and low-voltage analog and digital communication cables and fiber optic cables shall be located below control cable trays.

- 15 kV cables
- 5 kV cables
- Low-voltage power AC and DC 600 V cables
- High-level control signal or discrete on/off control cables (120 volts AC, 125 volts DC)
- Cables for general instrumentation (i.e., low-level analog and digital signals and data communication).

Technical Rationale—This criterion is required because higher-voltage cables are more prone to starting fires. In case of fire, generated heat will flow upward. This practice prevents damaging lower voltage cables in case of fire generated in higher-voltage cable trays. This is common practice in the industry.

4.3.1.9.7

Criteria—Cable rated at 300 V may be routed in the same raceway as 600 V cable and share the same enclosures (boxes), provided the maximum applied voltage of the 600 V cable does not exceed 300 V.

Technical Rationale—This criterion is required to prevent the mixing of 120 V low power or control circuit cables with 600 V class power cables. Very low-voltage power cables and control circuit cables are rated 300 V or below. This is the common practice in industry. (Although 300 V and 600 V cables belong to the low-voltage class, 600 V cables normally carry a higher amount of power).

4.3.1.9.8

Criteria—Conduit for power and instrumentation shall be rigid, galvanized steel. Lighting and receptacle conduit, which is exposed to the weather, shall be rigid galvanized steel with weatherproof fittings. Lighting and receptacle conduits in buildings and vaults may be electrical metallic tubing with rain tight fittings. The lighting system may use electrical metal tubing for concealed work in non-hazardous areas, such as offices and control rooms. Generally, PVC conduit shall be used for underground duct banks, except PVC-coated rigid, galvanized steel shall be used under heavy traffic areas. The minimum bend radius of fiber optic cable shall be reviewed during conduit design.

Technical Rationale—This is the common practice in industry for a reliable and long lasting raceway installation.

4.3.1.9.9

Criteria—All cable raceway that support functions of the emergency power subsystem, as a minimum, shall be designed and installed in accordance with NFPA 70-2004 [DIRS 172711].

Technical Rationale—This is common practice in the industry.

4.3.1.9.10

Criteria—All cable raceway that support functions of the emergency power subsystem and supports the function of ITS circuits cables shall be designed for a site-specific 1000-year return period earthquake. These raceway supports shall be qualified in accordance with ANSI/IEEE Std 344-1987 (Reaffirmed 1993), *IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations* [DIRS 159619].

Technical Rationale—This design criterion is based on the requirements of ANSI/IEEE Std 344-1987 (Reaffirmed 1993) [DIRS 159619].

4.3.1.10 Duct Banks and Manholes

4.3.1.10.1

Criteria—For underground installation, concrete encased underground duct banks and manhole systems shall be installed throughout the site for the pulling and protection of power, control, and instrumentation cables. Twenty percent conduit spare capacity shall be provided for underground duct banks.

Technical Rationale—This criterion is used to facilitate the cable routing between buildings or facilities. This is a common practice in industry for a reliable power distribution system.

4.3.1.10.2

Criteria—Manholes and pull points shall be used as required to facilitate cable pulling and inspection. Their sizes and locations shall depend on associated duct banks. The type and sizes of the cables to be installed shall be shown on the layout drawings. The maximum distance between manholes and pull points shall be as allowed by the NFPA 70-2004 [DIRS 172711]. Manholes and pull points shall be provided with appropriate drainage. A copper grounding pad shall be provided in each manhole. The pad shall be connected back to the main ground grid by AWG 4/0 copper cable.

Technical Rationale—This criterion is required to facilitate cable pulling activities. Grounding provision is for the protection of personnel and equipment. This is the common practice in industry for a reliable manhole installation.

4.3.1.10.3

Criteria—

- All electrical duct banks shall be designed for soil and traffic loads at road and railroad crossings. Traffic loading includes normal HS-20 truck loading and heavy transporter loading where applicable.

- Electrical duct banks shall be located at a depth of a 3-ft minimum cover top of duct bank to finish grade surface. Exceptions to the depth requirement shall be permitted for short portions of 10 percent or less of the entire length of the duct bank run.

- The minimum horizontal clearance between adjacent duct banks shall be 1 ft face to face except when another utility is a heat source, and then the horizontal clearace will be 3 ft.

Technical Rationale—This criterion is used to facilitate interfaces between the duct bank routing and other underground utilities. This is a common practice in industry for a reliable power distribution system.

4.3.2 Emergency Electrical Power Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Emergency Electrical Power[b]	ANSI/IEEE Std 344-1987 (Reaffirmed 1993), IEEE Std 141-1993, IEEE Std 446-1995, IEEE Std 484™-2002, IEEE Std 450-2002, IEEE Std 741-1997, NFPA 110-2005
		None
		None
		DOE O 420.1A, DOE G 420.1-1

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21 (c)(2) [DIRS 173273]), PRD-022, and the electrical power system. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] None.

[3] None.

[4] Addressing these DOE directives supports compliance with the requirements of PRD-018/P-019. Applicable sections of these DOE directives will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

The following criteria apply to the emergency power system in addition to the criteria listed in Section 4.3.1.

4.3.2.1

Criteria—The facility emergency power supply voltages shall be 4.16 kV, 480/277 V, and 208/120 V, 3-phase, 60 Hz for AC system. The DC battery system voltage shall be 125 V.

Technical Rationale—This criterion is required to define the facility application voltages in compliance with IEEE Std 141-1993 [DIRS 122242]. These voltages are commonly used in industry in the United States for medium- and low-voltage systems. Electrical equipment is most readily available in these voltages. Their performances have long been proven.

4.3.2.2

Criteria—All equipment in the emergency power subsystem, including the emergency diesel generators, shall be designed for site-specific 1000-year return period earthquake. Equipment qualification shall be in accordance with ANSI/IEEE Std 344-1987 (Reaffirmed 1993) [DIRS 159619], Section 9.

Technical Rationale—This criterion is to ensure that the emergency power subsystem is available after a seismic event to provide power to loads such as post-event monitoring systems, communications, egress lighting in defined areas, select HVAC units, and worker industrial and life safety systems (BSC 2004 [DIRS 167313]).

4.3.2.3

Criteria—The emergency power subsystem shall be designed with redundant 4.16 kV emergency switchgear buses. Each bus shall be designed such that electrical isolation and physical separation methods are applied to ensure that failures in one redundant load group will not cause failures to the other redundant load group or non-ITS equipment failures will not cause failures in ITS equipment. The implementation of these design enhancements for the ITS portion of the electrical power system shall be measured against applicable requirements in IEEE Std 384-1992, *IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits.* [DIRS 103105]. Each emergency switchgear bus shall be connected to an emergency diesel generator that will supply loads such as post event monitoring systems, communications, egress lighting in defined areas, select HVAC units, and worker industrial and life safety systems.

Technical Rationale—This criterion is to provide reliability and to ensure that the emergency power subsystem is available to provide power to redundant system loads.

4.3.2.4

Criteria—The emergency power subsystem includes a 4.16 kV emergency bus, 480 V emergency system, 125 VDC system, and 120 VAC UPS system. Redundant buses satisfy the single-failure criterion and ensure the availability of emergency power. Implementation of this single failure performance criterion will be based on IEEE Std 379-2000, *IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety* Systems [DIRS 166688]. The emergency power subsystem is designed to meet the requirements of IEEE Std 446-1995 [DIRS 125763] and NFPA 110-2005, *Standard for Emergency and Standby Power Systems* [DIRS 173511].

Technical Rationale—This criterion defines the requirements for the emergency power subsystem and ensures power is available to ITS loads, the safety functions of which will be needed after Category 1 event sequence.

4.3.2.5 Not Used

4.3.2.6 Not Used

4.3.2.7 Not Used

4.3.2.8 Not Used

4.3.2.9 Not Used

4.3.2.10 Not Used

4.3.3 Switchyard and Transmission Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Switchyard and Transmission[b]	ANSI/IEEE Std 944-1986, IEEE Std 1048™-2003, IEEE Std 1189-1996, IEEE Std 524™-2003, IEEE Std 525-1992, IEEE Std 80-2000, NFPA 70-2004
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022. Determination of applicable sections of these documents will be determined during the design process and in the development of design products.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

The following criteria will apply to the switchyard and transmission subsystem in addition to the criteria listed in Section 4.3.1.

4.3.3.1

Criteria—The switchyard located at the southwest corner of the North Portal facility area shall be used to receive power via 230 kV and 138 kV overhead transmission lines from the utility power company.

Technical Rationale—This criterion is required to define the entry point of utility power transmission lines.

4.3.3.2

Criteria—The switchyard shall be fenced and the access gate shall be locked to limit the access to only qualified workers. Coarse granite crushed rock will be provided to increase the ground resistance to the grounding grid and mitigate shock hazards.

Technical Rationale—This criterion is required to protect the safety of non-job-related personnel, as required in NFPA 70-2004 [DIRS 172711]. This is also a safeguard and security requirement.

4.3.3.3

Criteria—The 230 kV and 138 kV power at switchyards shall be stepped down to 12.47 kV by means of step-down transformers located in the switchyard.

Technical Rationale—This criterion is required to define the application voltage of the facility.

4.3.3.4

Criteria—The 230-12.47 kV stepdown transformer shall be the primary main transformer. It shall supply all facility loads normally. The 138-12.47 kV stepdown transformer shall be the standby main transformer. It shall supply selected facility loads when the primary main transformer is not available.

Technical Rationale—This criterion is required to define the roles of two main stepdown transformers.

4.3.3.5

Criteria—The 12.47 kV power output from the main transformer shall be connected to the 12.47 kV main switchgears in the switchyard switchgear building via underground duct banks or the overhead non-segregated phase bus.

Technical Rationale—This criterion is required to define the method of power line connection.

4.3.3.6

Criteria—All clearances between live conductors and for clearances between live conductors and equipment shall be in accordance with IEEE C2-2002, *National Electrical Safety Code* [DIRS 158848], Section 23.

Technical Rationale—This criterion is required to define the clearances for live parts.

4.3.3.7

Criteria—The 230 kV and 138 kV voltage and frequency shall be monitored and recorded to establish historical performance of the offsite power source.

Technical Rationale—This criterion is required to ensure adequate reliability is maintained by the offsite power source to supply the facility power distribution system as required by *Categorization of Event Sequences for License Application* (BSC 2005 [DIRS 174467]).

4.3.4 Normal Electrical Power Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Normal Electrical Power[b]	ANSI C84.1-1995, IEEE C2-2002, IEEE Std 141-1993, IEEE Std 142-1991, IEEE Std 242-2001, IEEE Std 446-1995, IEEE Std 739-1995, NFPA 1-2003, NFPA 70-2004, NFPA 780-2004, Rea 2000
		None
		29 CFR Part 1910
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the electrical power system. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] None.

[3] Addressing the CFR supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Applicable sections of this document will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.3.5 Safeguards and Security Design Criteria

4.3.5.1 Safeguards and Security Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Safeguards and Security[b]	Rea 2000, UL 437-2000, UL 768-1999
		NUREG-1065 (Joy 1995), NUREG-1280 (NRC 1995), Regulatory Guide 5.12, Regulatory Guide 5.26, Regulatory Guide 5.27, Regulatory Guide 5.44, Regulatory Guide 5.49, Regulatory Guide 5.52, Regulatory Guide 5.61, Regulatory Guide 5.62, Regulatory Guide 5.65, Regulatory Guide 5.68, Regulatory Guide 5.7
		10 CFR Part 63, 10 CFR Part 73, 29 CFR Part 1910
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the safeguards and security system. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing CFRs supports compliance with requirements in PRD-005, PRD-015/P-020, and PRD-015/P-021. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.3.5.2 Safeguards and Security Design Criteria

Requirements listed here are derived from *Repository Design Requirements: Safeguards and Security* (BSC 2004 [DIRS 171501]).

4.3.5.2.1

Criteria—Site physical barriers, building and perimeter surveillance systems and cameras, intrusion detection devices, intrusion alarms, access control systems, hazardous material tracking systems, and radiological safety and control systems shall be provided.

Technical Rationale—This criterion is required to define the scope of the safeguard and security system for the facility security and general and facility personnel.

4.3.5.2.2

Criteria—Access to the buildings that makes up the YMP facility shall be via automatic turnstiles actuated by individual passes under the supervision of a single site access control system. The access control system shall have the capability of granting or denying access at all points on an individual basis. The system shall record locations of personnel for the purposes of roll call following an incident. Access to this information shall be provided at the relevant security points.

Technical Rationale—This criterion is required to define the access control equipment.

4.3.5.2.3

Criteria—The GROA shall be provided with a primary alarm station that is separate from the CCCF. The primary alarm station facility shall have substantial penetration resisting walls, doors, ceilings, and floor. The primary alarm station shall monitor and assess system surveillance, detection, access/egress, and all other security alarm functions.

Technical Rationale—This criterion is required to monitor all functions of the safeguard and security requirements of the repository facility.

4.3.5.2.4

Criteria—To provide system redundancy, the facility shall be provided with an alternate alarm station that shall be located physically separated from the primary alarm station and close to the facility access point. The alternate alarm station shall monitor and alarm the same security alarming functions provided by the primary alarm station.

Technical Rationale—This criterion is required to provide redundancy to the primary alarm station.

4.3.6 Electrical Support Design Criteria

4.3.6.1 Electrical Support Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Electrical Support[b]	ANSI/IESNA RP-22-96, ANSI/NEMA 250-1997, ANSI/UL 467-1998, IEEE C2-2002, IEEE Std 1202-1991, IEEE Std 142-1991, IEEE Std 446-1995 (Grounding Only), IEEE Std 515™-2004, IEEE Std 739-1995, IEEE Std 80–2000, IEEE Std 81-1983, NACE Standard RP0169-2002, NFPA 1-2003, NFPA 780-2004, Rea 2000, UL 96A-2001
		None
		29 CFR Part 1910
		DOE O 420.1A

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] None.

[3] Addressing the CFR supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Applicable sections of this document will be determined during the design process and in the development of design products.

[4] Addressing this DOE order supports compliance with requirements of PRD-018/P-019. Applicable sections of this DOE order will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.3.7 Communication Design Criteria

4.3.7.1 Communication Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Communications[b]	ANSI/TIA-568-B.1-5-2004, ANSI/TIA-568-B.2-6-2003, ANSI/TIA/EIA-568.B.3-1-2002, IEEE 802.1Q™-2003, IEEE Std 802.11b-1999, IEEE Std 802.11j-2004, IEEE Std 802.3ah-2004, ISO/IEC 11172-1:1993, ISO/IEC 11172-2:1993, ISO/IEC 11172-3:1993, ISO/IEC 13818-1:2000, ISO/IEC 13818-2:2000, ISO/IEC 13818-3:1998, ITU-T Rec. G.703: 2002, ITU-T Rec. G.711:1993, ITU-T Rec. G.729:1996, Lee 1999, NFPA 70-2004, NFPA 75-2003, RFC 791 (Postel 1981), RFC 793 (Postel 1981), RFC 1155 (Rose and McCloghrie 1990), RFC 1541 (Droms 1993), RFC 1583 (Moy 1994), RFC 1812 (Baker 1995), RFC 1918 (Rekhter 1996), RFC 2401 (Kent and Atkinson 1998), RFC 2460 (Deering and Hinden 1998), RFC 2474 (Nichols et al. 1998), RFC 2979 (Freed 2000), RFC 3260 (Grossman 2002), RFC 3261 (Rosenberg et al. 2002), RFC 3344 (Perkins 2002), RFC 3376 (Cain et al. 2002), SMPTE-170M:1999, T1.105-2001, TIA 102 Series-2003 [DIRS 166835]
		None
		10 CFR Part 63, 47 CFR Part 15
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-022/P-001 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and the communications system. Applicable sections of this document will be determined during the design process and in the development of design products.

[2] None.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015 and PRD-002/T-013. Applicable sections of these documents will be determined during the design process and in the development of design products. Addressing CFRs supports compliance with requirements in PRD-015/P-020 and PRD-015/P021. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.3.7.2 SONET Backbone

Criteria—All repository communications shall be transported on a common SONET communications backbone in accordance with T1.105-2001, *Synchronous Optical Network (SONET) -- Basic Description Including Multiplex Structure, Rates, and Formats Including Supplement T1.105-2002* [DIRS 164162].

Technical Rationale—SONET is an extremely robust industry standard for data transport with protection against single point failures. SONET also affords a high degree of management and repair assistance.

4.3.7.3 Network Communications

Criteria—The operations, safeguards and security, administrative, ES&H, utility, and telephone networks shall comply with the internet protocols as required by RFC 791, *Internet Protocol, DARPA Internet Program Protocol Specification* (Postel 1981 [DIRS 167059]), and RFC 793, *Transmission Control Protocol, DARPA Internet Program Protocol Specification* (Postel 1981 [DIRS 167060]).

Technical Rationale—All network communications shall be compliant with the Internet to ensure expandability and interoperability while avoiding obsolescence.

4.3.7.4 Network Routing

Criteria—Network routers shall be utilized on the communications networks to manage and route data in accordance with RFC 1541, *Dynamic Host Configuration Protocol* (Droms 1993 [DIRS 164144]); RFC 1583, *OSPF Version 2* (Moy 1994 [DIRS 164146]); RFC 1812, *Requirements for IP Version 4 Routers* (Baker 1995 [DIRS 164147]); RFC 1918, *Address Allocation for Private Internets* (Rekhter et al. 1996 [DIRS 164148]); RFC 2460, *Internet Protocol, Version 6 (IPv6) Specification* (Deering and Hinden 1998 [DIRS 166818]); and RFC 3376, *Internet Group Management Protocol, Version 3* (Cain et al. 2002 [DIRS 164489]).

Technical Rationale—Network routing is necessary for all network communications to be interoperable, allow for rapid recovery in the event of failure, and allow for the central management of the communications networks.

4.3.7.5 Local Area Networking

Criteria—The communications system shall provide local area networking (LAN) components to connect interfacing devices to the communications system networks.

Technical Rationale—Provisions must be provided to interface with the communications system LANs in accordance with IEEE Std 802.3ah-2004, *IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications. Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks* [DIRS 172990].

4.3.7.6 Virtual Local Area Networks

Criteria—Sub-networks shall be created as virtual LANs out of specific communications networks in accordance with IEEE Std 802.1Q™-2003, *IEEE Standards for Local and Metropolitan Area Networks, Virtual Bridged Local Area Networks* [DIRS 166836].

Technical Rationale—Sub-networks integrated within larger networks are commonly used in industry as an economical alternative to creating additional communications networks.

4.3.7.7 Network Management

Criteria—Networks and network services shall be centrally managed from a network operations center in accordance with RFC 1155, *Structure and Identification of Management Information for TCP/IP- Based Internets* (Rose and McCloghrie 1990 [DIRS 166838]).

Technical Rationale—Network management is required to provide a smooth operation and efficient maintenance of the communications system networks.

4.3.7.8 Communications Security

Criteria—All traffic on the operations network, safeguards and security networks, all connections between the onsite administrative network, and the offsite BSC Las Vegas Intranet shall be secured with Internet Protocol Security in accordance with RFC 2401, *Security Architecture for the Internet Protocol* (Kent and Atkinson 1998 [DIRS 166819]).

Technical Rationale—Secure connections at the network layer are required for protection against malicious intrusions, interception, viruses, and spoofing.

4.3.7.9 Firewalls

Criteria—Firewalls shall be provided for the communications networks in accordance with RFC 2979, *Behavior of and Requirements for Internet Firewalls* (Freed 2000 [DIRS 166830]).

Technical Rationale—Firewalls provide protection against unauthorized access to the communications networks.

4.3.7.10 Encryption

Criteria—The communications networks and satellite links shall be encrypted in accordance with *Guideline for Implementing Cryptography in the Federal Government* (Lee 1999 [DIRS 166847]).

Technical Rationale—Encryption is required to enhance protection against malicious intrusions, interception, spoofing, and unauthorized access to the communications networks.

4.3.7.11 Emergency Communications

Criteria—Onsite and offsite communications shall be provided to coordinate and assess the emergency response activities.

Technical Rationale—Emergency communications is required to provide onsite emergency response capabilities and alert offsite organizations of repository emergencies.

4.3.7.12 Public Address System

Criteria—Live voice or pre-recorded messages shall be transported from the Emergency Operations Center and alarm center over a public address system. Public address voice traffic shall be transported using dual-tone multiple frequencies and in accordance with ITU-T Rec.

G.711, *General Aspects of Digital Transmission Systems, Terminal Equipments, Pulse Code Modulation (PCM) of Voice Frequencies* [DIRS 166880]. Subsurface public address systems will be hard wired voice communications.

Technical Rationale—A public address system is required to provide audible and clear spoken messages to all normally occupied areas of the surface and subsurface facilities during normal and off-normal conditions.

4.3.7.13 Alarms

Criteria—Alarm signals shall automatically activate within the facility from where such an alarm condition originates.

Technical Rationale—Alarms are required within the immediate area and throughout the repository to make personnel aware that potential hazards exist.

4.3.7.14 High Resolution Video

Criteria—High resolution video shall be provided to monitor commercial spent nuclear fuels (CSNF)/HLW waste package transport, transfer, processing, and aging operations in accordance with the MPEG-2 standard per ISO/IEC 13818-1 [DIRS 166812]; ISO/IEC 13818-2 [DIRS 166813]; and ISO/IEC 13818-3, *Generic Coding of Moving Pictures and Associated Audio Information - Part 1, 2 & 3* [DIRS 166814].

Technical Rationale—High resolution video is required to provide the digital control and management information system (DCMIS) the capability to monitor the various processing areas within the repository, including welding and closure cells and the waste package transportation and emplacement equipment.

4.3.7.15 Medium Resolution Video

Criteria—Medium resolution video shall be provided to transfer images from portable cameras to the fire control center and the Emergency Operations Center in accordance with the MPEG-1 standard per ISO/IEC 11172-1:1993/Cor.2 [DIRS 166931]; ISO/IEC 11172-2:1993/Cor.3 [DIRS 167695]; and ISO/IEC 11172-3:1993/Cor.1, *Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to About 1.5 Mbit/s—Part 1, Systems, Part 2, Video, and Part 3, Audio* [DIRS 167696].

Technical Rationale—Medium resolution video is required to provide near-real-time portable video communications for firefighter and ES&H personnel from on-scene locations to the control centers.

4.3.7.16 Closed Circuit Television

Criteria—The video communications network shall be capable of interfacing with analog closed circuit television (CCTV) cameras in accordance with SMPTE 170M, *SMPTE Standard for Television—Composite Analog Video Signal—NTSC for Studio Applications* [DIRS 167121].

Technical Rationale—The capability to interface with analog CCTV cameras is required because many of the CCTV cameras placed throughout the repository will only be capable of providing analog video signals.

4.3.7.17 Telephone Communications

Criteria—The repository shall be provided with wired and mobile and wireless telephone services via a telephone network. Mobile and wireless telephone services shall only be available in the subsurface. Wired and mobile and wireless telephone services shall be implemented in accordance with IEEE Std 802.11b-1999, *Supplement to IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band* [DIRS 164133]; RFC 2474, *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers* (Nichols et al. 1988 [DIRS 166885]); RFC 3260, *New Terminology and Clarifications for Diffserv* (Grossman 2002 [DIRS 166886]); RFC 3261, *SIP: Session Initiation Protocol* (Rosenberg et al. 2002 [DIRS 166815]); and RFC 3344, *IP Mobility Support for IPv4* (Perkins 2002 [DIRS 166817]).

Technical Rationale—Telephone communications is required to provide voice communication services for surface and subsurface facilities, including access to the public switched telephone network, during normal and off-normal (emergency) operations.

4.3.7.18 Voice Coder Decoder

Criteria—Each voice channel on the telephone network shall consume 8 kilobits per second of bandwidth in accordance with ITU-T Rec. G.729, *General Aspects of Digital Transmission Systems, Coding of Speech at 8 Kbit/s Using Conjugate - Structure Algebraic-Code-Excited Linear-Prediction (CS-ACELP)* [DIRS 166882].

Technical Rationale—Voice conversations can be carried efficiently and reliably at 8 kilobits per second without significantly reducing voice quality or clarity.

4.3.7.19 Telephone Trunk Lines

Criteria—The site telephone network shall connect to the public switched telephone network via conventional T-1 telephone trunk lines in accordance with ITU-T Rec. G.703, *Physical/Electrical Characteristics of Hierarchical Digital Interfaces, Series G: Transmission Systems and Media, Digital Systems and Networks, Digital Terminal Equipment—General* [DIRS 166824].

Technical Rationale—T-1 telephone trunk lines are one of the most common interfaces to the public switched telephone network.

4.3.7.20 Mobile Radio Communications

Criteria—Mobile radio communications shall be provided for firefighter, ES&H, and construction personnel in accordance with TIA 102 Series, *Project 25—The TIA-Published 102-Series Documents* (TIA 2003 [DIRS 166835]).

Technical Rationale—Mobile radios used by firefighter, ES&H, and construction personnel must be non-interfering and interoperable.

4.3.7.21 Wireless Communications

Criteria—Wireless communications shall be provided between the CCCF and waste package transportation and emplacement equipment in accordance with IEEE Std 802.11j-2004, *IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications–Amendment 7: 4.9 GHz-5GHz Operation in Japan* [DIRS 172992].

Technical Rationale—Wireless communications is the most practical method for communicating with a moving vehicle, as justified in the analyses performed in *Subsurface Waste Package Handling—Remote Control and Data Communication Analysis* (CRWMS M&O 1997 [DIRS 100252]) and *Design Analysis for the Yucca Mountain Project Communications System* (BSC 2003 [DIRS 165551]).

4.3.7.22 Electromagnetic and Radio Frequency Interference

Criteria—All wireless communications shall meet conventional electromagnetic compatibility (EMC) standards to prevent interference with radio frequency communications within and external to the communications system.

Technical Rationale—Design and installation practices must mitigate and minimize the effects of electromagnetic interference and radio frequency interference (RFI) in accordance with 47 CFR Part 15, Telecommunication: Radio Frequency Devices [DIRS 173345].

4.3.7.23 Offsite Tracking

Criteria—Vehicles transporting nuclear waste casks to the repository shall have the capability to continuously transmit and receive secured wireless communications.

Technical Rationale—Secured wireless communications with the transport vehicles is required to ensure continuous offsite tracking while in transport and for the purpose of accounting and acceptance in the repository. Voice communications is required with the transport operator.

4.3.7.24 Offsite Information Transfer

Criteria—Selected video, voice, and data information shall be transported to predesignated offsite DOE and Management and Operating Contractor (M&O) locations in a secure manner.

Technical Rationale—Offsite information transfer is required to provide near-real-time monitoring, but not control, of nuclear waste transfer, processing, transportation, and emplacement operations in the repository.

4.3.7.25 Design and Installation of Communications Structures, Systems, and Components

Criteria—All design, installation, and wiring of communications SSCs shall be in accordance with applicable sections of the latest versions of the following codes and standards:

- NFPA 70-2004, *National Electrical Code* [DIRS 172711].
- NFPA 75-2003, *Standard for the Protection of Information Technology Equipment* [DIRS 167085].

Technical Rationale—The codes and standards listed above directly apply to communications SSCs to be implemented at the repository. The latest revision of codes and standards is as defined in Section 1.2.

4.3.7.26 Telecommunications Building Wiring

Criteria—Telecommunications wiring for each particular building shall be in accordance with ANSI/TIA-568-B.1-5-2004, *Commercial Building Telecommunications Cabling Standard—Part 1: General Requirements—Addendum 5—Telecommunications Cabling for Telecommunications Enclosures* [DIRS 169804]; ANSI/TIA-568-B.2-6-2003, *Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components, Addendum 6—Category 6 Related Component Test Procedures* [DIRS 170590]; and ANSI/TIA/EIA-568 B.3-1-2002, *Optical Fiber Cabling Components Standard, Addendum 1—Additional Transmission Performance Specifications for 50/125 um Optical Fiber Cables* [DIRS 170591].

Technical Rationale—Buildings must be wired appropriately to support their particular telecommunications requirements.

4.3.8 Important to Safety Electrical

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Electrical Power System and Electrical Support[b]	ANSI/IEEE Std 944-1986, IEEE Std 323™-2003, IEEE Std 650-1990, IEEE Std 383™-2003, IEEE Std 1184-1994, IEEE Std 946-1992
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.3.8.1 System Design

The criteria listed in this section are only applicable to portions of the electrical power and support system classified as ITS. The criteria listed in this section are in addition to those listed in Sections 4.3.1 through 4.3.7.

The following design enhancement is described in specific project design criteria and shall be in addition to the requirements listed in commercial and industrial standards. This design enhancement shall only be applicable to the ITS portions of the electrical power system.

Equipment Qualifications—The primary objective of qualification is to demonstrate with reasonable assurance that electrical power system equipment can perform the safety function(s) without experiencing common-cause failures before, during, and after a design basis event. ITS portions of the electrical power system are subject to programs including, but not limited to, design control, quality control, equipment qualification, installation, maintenance, periodic testing, and surveillance. Since the electrical equipment (with the exception of electrical cables) related to the ITS portion of the electrical power system is located in a mild environment and not subject to significant aging mechanisms, a qualified life program for this equipment is not required. A maintenance and surveillance program based on vendor recommendations, which may be supplemented with operational experience, is provided to ensure that ITS equipment meets specified requirements. This program will follow the guidelines of IEEE Std 323™-2003, *IEEE Standard Qualifying Class 1E Equipment for Nuclear Power Generating Stations* [DIRS 166907].

Qualifications for the electrical cables for the ITS portion of the electrical power system that will be located in harsh environments are discussed in Section 4.3.8.1.2.

4.3.8.1.1

Criteria—The portion of the electrical power and electrical support systems that are classified as ITS is defined in the *Q-List* (BSC 2005 [DIRS 174269]).

Technical Rationale—This *Q-List* (BSC 2005 [DIRS 174269]) provides a list of electrical power and electrical support systems, structures, and components that are classified as ITS.

4.3.8.1.2

Criteria—The cables classified as ITS and located in harsh environments shall be qualified in accordance with IEEE Std 383™-2003, *Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations* [DIRS 171695].

Technical Rationale—This criterion is required to ensure that the cables used in ITS applications in high radiation environments are designed to provide reliable and timely power for their intended safety functions.

4.3.8.1.3

Criteria—As described in Section 4.3.8.1, the ITS portions of the electrical power and electrical support systems are subject to programs including, but not limited to, design control, quality control, equipment qualification, installation, maintenance, periodic testing, and surveillance. Equipment qualification is based on applicable portions of IEEE Std 323™-2003 [DIRS 166907], and cable qualification is based on IEEE Std 383™-2003 [DIRS 171695].

Technical Rationale—This criterion is required to ensure that the equipment used in ITS applications is designed to provide reliable and timely power for their intended safety functions.

4.3.8.1.4

Criteria—In addition to the standards listed in Sections 4.3.1 and 4.3.2, the UPS that have been classified as ITS shall also be designed in accordance with the following standards: ANSI/IEEE Std 944-1986, *IEEE Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations* [DIRS 166684], and IEEE Std 1184-1994, *IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems* [DIRS 164267]. The maintenance and surveillance program is based on IEEE Std 650-1990, *IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations* [DIRS 145720].

Technical Rationale—This criterion is required to ensure that the equipment used in ITS applications is designed to provide reliable and timely power for their intended safety functions.

4.3.8.1.5

Criteria—In addition to the standards listed in Sections 4.3.1 and 4.3.2, the 125 V direct current systems that have been classified as ITS shall also be designed in accordance with the following standards: IEEE Std 946-1992, *IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations* [DIRS 145722], and IEEE Std 650-1990.

Technical Rationale—This criterion is required to ensure that the equipment used in ITS applications is designed to provide reliable and timely power for their intended safety functions.

4.4 NOT USED

4.5 GEOTECHNICAL DESIGN CRITERIA

4.5.1 Applicable Codes and Standards

Applicable Discipline	Disciplines/ SSCs	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Geotechnical	Geotechnical	ACI 318-02/318R-02, ACI 349-01, ACI 506.2-95, ACI 506R-90(95), AISC 1997, ASTM A 185-01, ASTM A 242/A 242M-03a, ASTM A 276-03, ASTM A 36/A 36M-04, ASTM A 588/A 588M-03, ASTM A 820-01, ASTM C 1116-97, ASTM C 1240-01, ASTM C 150-02, ASTM C 494/C 494M-99a, ASTM E 136-99, ASTM F 432-95 (Reapproved 2001), UCRL-15673 (Bongarra et al. 1985), ICC 2000 [DIRS 159179]
		None
		29 CFR Part 1910
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] None.

[3] Addressing the CFR supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Applicable sections of this document will be determined during the design process and in the development of design products

[4] None.

[5] Safety classifications are only provided for SSCs.

[6] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.5.2 Ground Support Design Criteria

4.5.2.1 Functional and Performance Criteria

4.5.2.1.1

Criteria—The ground support shall be designed to maintain adequate operating envelopes during preclosure for the following subsurface openings: emplacement drifts, turnouts, access mains, portals and access ramps, exhaust air mains and raises, ventilation shafts, performance confirmation openings, and miscellaneous support openings. The ground support shall allow for the expected variations in excavated opening dimensions, lining thickness, alignment, and deformation.

Technical Rationale—10 CFR 63.111(e)(1) [DIRS 173273] requires that the waste retrieval option be maintained by assuring safe access to waste packages, retrieval operations, and installed components for purposes of testing, inspection, and maintenance. The ground support ensures that safe access to the emplacement drifts as well as all other subsurface openings is maintained. Therefore, this criterion supports this requirement.

4.5.2.1.2

Criteria—The ground support shall include provisions that support a deferral of closure for up to 300 years after final waste emplacement, with appropriate monitoring and maintenance.

Technical Rationale—This criterion in the PRD (Canori and Leitner 2003 [DIRS 166275], PRD-014/T-006) establishes the maximum length of time that the system will have to operate to provide the safe accessibility of stable underground openings for these purposes.

4.5.2.1.3

Criteria—The ground support shall accommodate geologic mapping of emplacement drifts, and allow for geologic mapping (full periphery mapping) of all of the nonemplacement drift openings in such a manner that the observation and recording of rock mass conditions during construction and operation can also be accomplished.

Technical Rationale—10 CFR 63.132(a) [DIRS 173273] requires that a continuing program of surveillance, measurement, testing, and geologic mapping be conducted to ensure that geotechnical and design parameters are confirmed and that appropriate action is taken to inform the NRC of needed design changes to accommodate actual field conditions. Thus, a criterion to accommodate geologic mapping is needed because the ground support design affects mapping capabilities. The rationale for mapping emplacement drifts is that this frequency of mapped drifts will ensure the detection of rock mass features (e.g., faults) anticipated to possibly affect repository performance. The rationale for mapping (full periphery mapping) all nonemplacement drift openings is to provide appropriate coverage for the confirmation of rock mass quality conditions, fracture statistics, and lithophysal porosity characteristics, and to supplement the technical bases for assessing overall performance of non-emplacement openings.

4.5.2.1.4

Criteria—The Subsurface Facility shall provide for the monitoring of ground support performance parameters including, as a minimum, opening convergence, condition of ground support, and rock and ground support temperatures.

Technical Rationale—To comply with 10 CFR 63.111(d) and 10 CFR 63.132(e) [DIRS 173273], in situ monitoring of the thermomechanical response of the underground facility is required. This criterion is provided to ensure monitoring capabilities of ground control performance parameters. The parameters to be monitored include opening convergence, ground support, and rock and ground support temperatures, and ground support loads. Opening convergence is monitored to ensure that the required clearances are being maintained. Ground support and rock temperatures are monitored to confirm that thermal design limits are not exceeded. Ground support loads are monitored to confirm if actual loads are within design limits.

4.5.2.1.5

Criteria—The ground support shall be designed to account for the appropriate worst possible case in terms of combinations of in situ, thermal, seismic, construction, and operation loads.

- **In Situ Load**—In situ loads are the stresses existing prior to the excavation of underground openings. Lower and upper bounds of horizontal-to-vertical stress ratios shall be used, together with the maximum vertical stress at the repository host horizon.
- **Thermal Load**—Thermal loads come from the elevated temperature caused by the heat released from emplaced waste packages. Since the rock mass surrounding underground openings and ground support components are subject to confinement from the cooler rock mass farther away, and cannot expand freely, the constrained thermal expansion induces thermal stress in the rock mass and ground support components. The higher the temperature, the higher the induced stress. The maximum normal operational temperature (at the emplacement drift wall) shall be accounted for in ground support design, together with design consideration of the maximum off-normal temperature limits specified in Section 6.3.
- **Seismic Load**—Analyzing the behaviors of unsupported underground openings subjected to vibratory ground motions caused by potential design basis earthquakes is an essential step towards designing an adequate ground support system and supporting the PSA with needed information on maximum credible rockfalls. For all unsupported and supported underground openings, the seismic load will be designed for a 2,000-year return period seismic event. Ground support for emplacement drifts will also be analyzed under a seismic load corresponding to a 10,000-year return period seismic event (Section 4.2.2) for assessment of design sensitivity and in consistency with drift degradation analyses that support the Total System Performance Assessment (TSPA). Both levels of vibratory ground motion correspond to a subsurface location at Point B shown in Figure 6.1.3-1.
- **Construction Load**—Construction loads such as tunnel boring machine weight and installation loads shall be considered only if they affect ground support.
- **Operation Load**—Operation loads such as waste package weights shall be considered only if they affect ground support.

Technical Rationale—System safety requires that all the underground openings be designed to minimize the potential for deleterious rock movement or fracturing so that operations can be carried out safely. This criterion is provided to ensure the adequacy of the ground support system by accounting for the worst-case loads and load combinations.

4.5.2.1.6

Criteria—The ground support shall be designed to prevent rockfalls that could result in personnel injury.

Technical Rationale—Personnel safety requires that underground openings be designed to minimize the potential for deleterious rock movement or fracturing so that underground operations can be carried out safely. To provide for safe operations, this criterion ensures a ground support system design that minimizes the potential of immediate or progressive failure (due to gradual deterioration) of the surrounding rock mass and deleterious rock movement that could result in unsafe subsurface conditions.

4.5.2.1.7

Criteria—The ground support system for emplacement drifts shall be designed with an adequate safety margin.

Technical Rationale—The safe in-drift operation under the condition of none-to-limited ground support maintenance in emplacement drifts is an important consideration in repository design. This criterion will ensure that the design will provide conditions for safety and help minimize maintenance of the ground support in emplacement drifts.

4.5.2.1.8

Criteria—The ground support system for accessible nonemplacement openings shall be designed for safety factors compatible with maintenance plans.

Technical Rationale—The safe maintenance of the ground support in the accessible nonemplacement openings is an important consideration in repository operations. This criterion will ensure that the design will permit the safe maintenance of the ground support.

4.5.2.1.9

Criteria—The inspection plan and maintenance strategy shall be an integral part of the ground support design.

Technical Rationale—The design of the ground support system should facilitate the planned inspection and maintenance of the ground support. This criterion will assist in ensuring that the design will be compatible with conducting planned inspections and maintenance during repository operations.

4.5.2.1.10

Criteria—The geotechnical instrumentation program shall be designed to facilitate and support the performance confirmation program, and confirm geotechnical data and design parameters, including thermomechanical responses and strength degradation of the rock mass.

Technical Rationale—10 CFR 63.111(d) [DIRS 173273] requires that a performance confirmation program be implemented within the GROA through permanent closure. 10 CFR 63.132(a) states that a specific requirement of this performance confirmation program is to provide a continuing program of surveillance, measurement, testing, and geologic mapping during repository construction and operation to confirm geotechnical and design parameters, including the thermomechanical responses and strength degradation of the rock mass. This criterion will ensure that the geotechnical instrumentation system will provide the necessary monitoring data for the confirmation of these parameters.

4.5.2.1.11

Criteria—The ground support shall be based on the site-specific geotechnical data that (1) are obtained from the laboratory and field investigations of the rock from or at Yucca Mountain, (2) comply with requirements for traceability and transparency, (3) account for spatial variability of rock strata, and (4) provide a representative geotechnical characterization of the rock mass and in situ environment.

- **Geotechnical Data**—Data that include intact rock and rock mass strength parameters, elastic modulus, Poisson's ratio, porosity, density, thermomechanical properties (specific heat, thermal conductivity, and coefficient of linear thermal expansion), and their dependence on time and temperature.

- **Data Traceability**—The ability to trace the history, original testing conditions, application, qualification status, and location of data and parameters using recorded documentation.

- **Data Transparency**—A data process that is sufficiently detailed as to purpose, data gathering, analysis and interpretation methodology, data quality appraisal, storage, and record keeping so that a person technically qualified in the subject can understand the process and the supporting documentation and verify their adequacy without recourse to the originator or the originating organization.

- **Spatial Variability**—A data attribute that must be taken into account to ensure that data representativeness for engineering application to the design of the repository openings.

- **Representativeness**—A quality measure of the adequacy of data for their engineering application.

Technical Rationale—Repository safety and operability requires that all underground openings are designed to minimize the potential for deleterious rock movement or fracturing. Natural variability of rock strata requires that information obtained from underground excavations and field and laboratory testing is properly gathered, analyzed, preserved, and used as input to confirm and improve the adequacy of the design. These data provide a reliable basis for periodically evaluating and appraising ground control measures such that stability and safety of underground excavations is maintained. This criterion is provided to ensure that adequate and representative rock and rock mass geotechnical rock property data are used to design and evaluate the performance of the excavations and the associated ground support systems.

- **Geotechnical Data**—These data are used to characterize and quantify the behavior and response of rock to the particular combination of loads imposed during the test or encountered in the field in response to excavation, method of ground support, and natural and operational factors.

- **Data Traceability**—By establishing traceability, the accuracy and applicability of data can be audited and verified by a person technically qualified in the subject. Such a requirement is described in the QARD (DOE 2004 [DIRS 171539], Supplement III.2.3).

- **Data Transparency**—A data transparency requirement is described in the QARD (DOE 2004 [DIRS 171539], Supplement III.2.4). With clear transparency, data used in the design can be independently obtained from the database and verified. Data transparency provides assurance that the data integrity and traceability of design are preserved at any stage of the project.

- **Spatial Variability**—The underlying Yucca Mountain geology shows considerable variation in rock properties with depth, particularly porosity, and an effort is made to model this variability using refined models (lithostratigraphic zones) of the rock as well as more detailed vertical variations within some sub-zones where they can be identified. The geologic heterogeneity present in Yucca Mountain rock, especially in the lithophysal rock, means that even a nearby sample of rock can have different properties. As a consequence, any effort to determine the imprecision of rock measurements (random error or statistical variation) is compromised by the spatial variation of rock properties. In geology and geomechanics, professional judgment is implicit in the process of determining uncertainties and variability, and it is used in geotechnical data interpretation. The development of the repository will reveal the true nature of rock mass variability, and its documentation and affect on design will require periodic evaluations of geotechnical rock property data in the context of underground excavation and surrounding rock mass performance and the adequacy of the corresponding ground support design.

- **Representativeness**—The current knowledge of rock properties is derived from the portion of the repository host rock horizon penetrated by exploratory drillings and underground excavations (i.e., Exploratory Studies Facility, Enhanced Characterization of the Repository Block Cross Drift, and a number of alcoves). Questions remain on how representative these rock property data are with respect to the entire area of the repository. In the event of major deviation, the new properties will be incorporated into the design. During repository development, each new excavation will be a source of new rock property data, thus enriching the existing rock property database. Periodical evaluation of the new information and existing data will be required to ensure that opening stability is preserved and ground support design is appropriate for the conditions encountered at various repository locations.

4.5.2.2 Ground Support Materials in Emplacement Areas

4.5.2.2.1

Criteria—The ground support shall use materials having acceptable (i.e., acceptability based on the results of waste isolation site impact evaluations) long-term effects on waste isolation.

Technical Rationale—10 CFR 63.113(b) [DIRS 173273] requires the engineered barrier system to be designed so that working in combination with natural barriers it will limit the expected annual dose after permanent closure. Ground support materials remaining after permanent closure may have chemical or other effects on the ability of the engineered and natural barriers to provide this assurance. This criterion ensures that the ground support materials do not impede the long-term waste isolation performance of the engineered and natural barriers.

4.5.2.2.2

Criteria—Steel for ground support (friction type rock bolts and perforated sheets) in emplacement drifts shall conform to ASTM A 276-03 [DIRS 165006], Type 316 (equivalent or better corrosion resistance).

Technical Rationale—Friction-type rock bolts and perforated sheets are required to function during the preclosure period. Stainless steel or corrosion-resistant material is recommended.

4.5.2.2.3 Not Used

4.5.2.3 Ground Support Materials in Nonemplacement Areas

4.5.2.3.1

Criteria—Steel for rock bolts in nonemplacement openings shall conform to ASTM A 615/A 615M-01b [DIRS 158033] and ASTM F 432-95 (Reapproved 2001) [DIRS 165010]. Welded wire fabric shall conform to ACI 318-02/318R-02 [DIRS 158832], Appendix E, and ASTM A 185-01 [DIRS 157994]. Lattice girders shall conform to ASTM A 36/A 36M-04 [DIRS 169609], ASTM A 325-02 [DIRS 158936], and ASTM A 706/A 706M-01 [DIRS 159360].

Technical Rationale—Ground support design in nonemplacement openings will conform to common practices and industry standards.

4.5.2.3.2

Criteria—Cement grout used for encapsulating rock bolts in nonemplacement openings shall be based on Portland cement (ASTM C 150-02 [DIRS 158105]), silica fume (ASTM C 1240-01 [DIRS 158843]), superplasticizer, and admixtures (ASTM C 494/C 494M-99a [DIRS 154218]). Grout durability and overall performance under normal operation and off-normal temperature limits shall be considered in engineering design.

Technical Rationale—Cement grout used for rock bolts will conform to industry standards and site-specific application conditions.

4.5.2.3.3

Criteria—Fiber reinforced shotcrete used as ground support shall conform to ASTM C 1116-97 [DIRS 158684]. Reinforcement fibers shall conform to ASTM A 820-01 [DIRS 158841]. Shotcrete durability and overall performance under normal operation and off-normal temperature limits shall be considered in engineering design.

Technical Rationale—Fiber reinforced shotcrete will conform to industry standards and site-specific application conditions.

4.5.2.3.4

Criteria—The ground support system shall use noncombustible and heat resistance material as defined by ASTM E 136-99, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C* [DIRS 158845].

Technical Rationale—System safety requires, to the extent practicable, the GROA be designed to incorporate the use of noncombustible and heat resistant materials. It is important to fire safety that the ground support materials be noncombustible and heat resistant. Material is considered noncombustible per ASTM E 136-99 [DIRS 158845], which is a standard accepted by the NRC. This criterion contributes to underground fire safety.

4.5.2.4 Emplacement Drift Environmental Conditions

Criteria

- The maximum emplacement drift wall temperature during preclosure is consistent with those identified in Section 6.3.
- The maximum in-drift relative humidity and the maximum relative humidity inside the boreholes drilled for installing rockbolts shall be considered in addressing the longevity of ground support components.
- Chemical compositions of site-specific groundwater shall be considered in evaluating the longevity of ground support components.

Technical Rationale—The maximum emplacement drift wall temperature is one of the key factors impacting the performance of the supported drift. The relative humidity and chemical compositions of site-specific groundwater are important to corrosion assessment for steel ground support components. The relative humidity values inside emplacement drifts and inside the boreholes drilled for installing rockbolts are based on a calculation (BSC 2003 [DIRS 165425], Section 7).

4.5.2.5 System Interfacing Criteria

4.5.2.5.1

Criteria—The ground support design shall interface with the subsurface development and emplacement drift subsystems (subsystems of the subsurface facility) to accommodate opening orientation, configuration, and excavated opening sizes.

Technical Rationale—The underground opening size, drift configuration, and drift orientation have a significant affect on ground support design. This criterion ensures that ground support design interfaces with the subsurface development and emplacement drift subsystems with respect to these parameters.

4.5.2.5.2

Criteria—The ground support system shall interface with the TSPA (natural and engineered barrier systems) to ensure general acceptance of committed ground support materials.

Technical Rationale—To comply with the postclosure performance requirements of 10 CFR 63.113(b) [DIRS 173273], the interface between the ground support system and TSPA has to ensure that ground support materials are compatible with long-term waste isolation objectives. The ground support material used in the emplacement drifts will remain there during the postclosure period. Therefore, this criterion ensures a ground support system design that does not impede the long-term performance of the natural and engineered barrier systems.

4.5.2.6 Operational Criteria

4.5.2.6.1

Criteria—The ground support for emplacement drifts and nonaccessible nonemplacement areas shall be designed to function without planned maintenance during the operational life, while providing for the ability to perform unplanned maintenance in the emplacement drifts and non-accessible nonemplacement areas on an as-needed basis.

Technical Rationale—After waste emplacement, the environmental conditions in the emplacement drifts and non-accessible nonemplacement drifts will be too harsh for human entry. Therefore, planned ground support repairs, which would require retrieving waste packages, should be avoided or at least minimized. This criterion ensures that the ground support system is designed to function during the preclosure period without planned maintenance. Due to the length of service life and the number of unknown factors that can affect ground support (e.g., amount of convergence, ground relaxation, seismic conditions), design has to account for the inherent uncertainties. Therefore, ground support design will not prevent the ability to perform unplanned maintenance, if required.

4.5.2.6.2

Criteria—The ground support shall accommodate the maintenance of accessible nonemplacement openings.

Technical Rationale—Due to the possibly long operational life of the ground support system, this criterion is provided to allow or accommodate either planned or unplanned maintenance of the ground support in the accessible nonemplacement openings. This will ensure the safe accessibility of the subsurface openings over the operational life of the repository.

4.6 INSTRUMENT AND CONTROL DESIGN CRITERIA

4.6.1 Digital Control and Management Information and Non-ITS Process Control System Design Criteria

4.6.1.1 Digital Control and Management Information and Non-ITS Process Control System Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Instrumentation and Control	Digital Control and Management Information System and Non-ITS Process Control Systems[b]	ANSI/IEEE Std 260.1-1993, ANSI/IEEE Std 344-1987 (Reaffirmed 1993), ANSI/ISA S5.2-1976 (R1992), ANSI/ISA-5.1-1984 (R1992), IEEE Std 1023-1988, IEEE Std 1100-1999, IEEE Std 1289-1998, IEEE Std 802.3ah-2004, ISA-18.1-1979 (R2004), ISA-5.3-1983, ISA-S5.5-1985, NEMA ICS 1-2000, NEMA ICS 6-1993 (R2001)
		NUREG-0700 (O'Hara et al. 2002), Regulatory Guide 1.12, Regulatory Guide 1.21, Regulatory Guide 1.23, Regulatory Guide 1.62, Regulatory Guide 8.8
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, the DCMIS, and non-ITS process control systems. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] This NUREG has been determined to be useful to the development of design products for the preliminary design. These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.6.1.2 Digital Control and Management Information and Non-ITS Process Control System Design Criteria

4.6.1.2.1

Criteria—The system shall provide real time monitoring, control, and data acquisition for the facility. Operator graphics from which control and monitoring are done shall be designed in accordance with guidelines contained in IEEE Std 1289-1998, *IEEE Guide for the Application of Human Factors Engineering in the Design of Computer-Based Monitoring and Control Displays for Nuclear Power Generating Stations* [DIRS 164225]; ISA-S5.5-1985, *Graphic Symbols for Process Displays* [DIRS 164283]; ANSI/IEEE Std 260.1-1993, *American National Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain*

Other Units) [DIRS 164235]; and applicable sections of NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]).

Technical Rationale—This criterion is required to ensure there is a means to control and monitor facility operations at all times.

4.6.1.2.2

Criteria—The system shall provide alarms, operator messages, and status indications. The design of the presentation of alarms, messages, and indications shall be in accordance with guidelines contained in IEEE Std 1289-1998 [DIRS 164225]; ISA-18.1-1979 (R2004), *Annunciator Sequences and Specifications* [DIRS 171932]; as applied in Appendix A.5; and applicable sections of NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]).

Technical Rationale—This criterion is required to provide a facility wide capability to detect abnormalities or off-normal events.

4.6.1.2.3

Criteria—The system shall provide data logging and trending. The design of trends and reports shall be in accordance with guidelines contained in IEEE Std 1289-1998 [DIRS 164225].

Technical Rationale—This criterion is required to collect and provide backup storage for operational data and support of performance confirmation.

4.6.1.2.4

Criteria—A CCTV system shall be provided for remote viewing of equipment and operations. The video from the cameras shall be displayed on the human machine interface consoles.

Technical Rationale—The requirement for CCTV is based on good engineering practice and the design of other similar facilities and is required to provide the operator with a means to view operations being conducted in areas where radiation levels prohibit human occupation.

4.6.1.2.5

Criteria—The system shall provide the ability to make configuration changes. Engineering configuration work shall be performed in accordance with ANSI/ISA-5.1-1984 (R1992), *Instrumentation Symbols and Identification* [DIRS 166742]; ANSI/ISA S5.2-1976 (R1992), *Binary Logic Diagrams for Process Operations* [DIRS 164286]; and ISA-5.3-1983, *Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems* [DIRS 164263].

Technical Rationale—This criterion is required to facilitate a periodic adjustment and/or reconfiguration of the system or part of the system in order to accommodate future upgrades or refurbishment.

4.6.1.2.6

Criteria—Each data point from field devices shall be assigned a unique tagname. Tagnames shall be created in accordance with ANSI/ISA-5.1-1984 (R1992) [DIRS 166742].

Technical Rationale—This criterion is required to provide a means to uniquely identify data in the system.

4.6.1.2.7

Criteria—System components that could be a single point of failure shall be redundant. The requirement for redundancy possibly includes, but not limited to, processors, power supplies, network cables, and network interface devices. Use of redundant system components shall be evaluated on a case-by-case basis.

Technical Rationale—The requirement for redundancy is based on good engineering practice and standard industry practice and is required to ensure system reliability.

4.6.1.2.8

Criteria—The system shall have spare installed capacity. This includes spare capacity for input/output modules, terminations, and controllers.

Technical Rationale—This criterion is required to accommodate immediate future growth.

4.6.1.2.9

Criteria—The system shall have space for future growth. This shall include input and output space and allowance for additional nodes.

Technical Rationale—This criterion is required to accommodate long-term future growth capacity.

4.6.1.2.10

Criteria—The system shall be comprised of fully modular components to the maximum extent possible.

Technical Rationale—This criterion is required to allow provisions for future upgrades or refurbishment to the maximum extent possible.

4.6.1.2.11

Criteria—The system components shall be removable and installable under the maximum power.

Technical Rationale—This criterion is required to enable the online replacement and maintenance of components. This will reduce or eliminate down time to the maximum extent possible.

4.6.1.2.12

Criteria—The system components shall function normally if installed in radiation environments.

Technical Rationale—This criterion is required so that components susceptible to radiation can withstand and operate in their radiation environment.

4.6.1.2.13

Criteria—The system shall provide built-in-test capabilities and perform self-diagnostics.

Technical Rationale—This criterion is required to perform system maintenance and trouble shooting without affecting the performance of the system.

4.6.1.3 Control Areas

4.6.1.3.1

Criteria—A CCCF shall be provided for the facility and located on the surface. The design and layout of the CCCF shall be in accordance with guidelines contained in IEEE Std 1023-1988, *IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations* [DIRS 124974], and applicable sections of NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]).

Technical Rationale—This criterion is required to provide a central area from which facility operations can be monitored and controlled.

4.6.1.3.2

Criteria—The CCCF shall house human machine interface consoles to control and monitor selected areas of the GROA. Each console shall have the ability to access and control functions available in the system. Human machine interface consoles shall be designed in accordance with guidelines contained in IEEE Std 1023-1988 [DIRS 124974], IEEE Std 1289-1998 [DIRS 164225], NEMA ICS 6-1993 (R 2001) [DIRS 164222], applicable sections of NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]), and in consideration of OSHA ergonomic factors guidelines.

Technical Rationale—Human machine interface consoles are required to ensure that various operators have access to required operations for the facility simultaneously. Human machine interfaces provide the current technology for providing access and monitoring capability for plant operations.

4.6.1.3.3

Criteria—Control capabilities shall be provided locally. The design of local control consoles shall be in accordance with guidelines contained in IEEE Std 1023-1988 [DIRS 124974], IEEE Std 1289-1998 [DIRS 164225], NEMA ICS 6-1993 (R2001) [DIRS 164222], applicable sections of NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]), and in consideration of OSHA ergonomic factors guidelines.

Technical Rationale—Due to the nature of some operations in the facility, it is recommended that control capabilities be available close to the system so that the operator can view operations while controlling.

4.6.1.3.4

Criteria—Video and operator controls shall be provided outside the transfer cells and at other areas where required (e.g., at local control consoles) and also in the CCCF. Control features such as pan, tilt, and zoom shall be selectable at any location where an operator requires a variable view to assist in operations.

Technical Rationale—The requirement for video is based on good engineering practice and the design of other similar facilities. A video system is required for remote viewing of equipment and operations within areas where the radiation levels are too high for personnel access and onboard the transporter.

4.6.1.3.5

Criteria—A multi-level user password or similar system shall be provided to control access to specific control functions.

Technical Rationale—The requirement for system password or similar security is based on good engineering practice and standard industry practice and is required to provide the operator with a secure means by which to interface the facility.

4.6.1.3.6

Criteria—An engineering configuration room shall be provided separate from the CCCF to provide a separate engineers console to perform on and off line functions such as configuration of new control and monitor points, changes or additions to graphic displays, and calibration changes/updates to control and monitor instrumentation. The engineering configuration room is not intended to be a separate control room. It is intended to perform activities not related to operations.

Technical Rationale—The requirement for an engineering configuration room is based on NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]) and is intended to comply with the requirement to limit access and movement of nonessential, but authorized, personnel to prescribed areas within the CCCF. The engineering configuration room will be used to perform tasks not related to daily operations of waste emplacement but rather to update the configuration of the repository as the surface and subsurface areas continue to be developed over the phased construction and emplacement period.

4.6.1.3.7

Criteria—Environmental considerations in the CCCF and engineering configuration room shall be in accordance with guidelines contained in IEEE Std 1023-1988 [DIRS 124974] and applicable sections of NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]).

Technical Rationale—This criterion is required to ensure that temperature, airflow, humidity, illumination, and acoustics are controlled within a comfort zone preferred by personnel. When conditions are outside the comfort zone, it can be a detriment to human performance.

4.6.1.3.8

Criteria—System printers shall be provided in the CCCF to print shift reports, alarm messages, and other administrative reports relating to the system operation. An engineering printer may be provided in the engineering configuration room to record configuration changes, produce engineering reports and calibration records, and perform similar engineering related activities.

Technical Rationale—The requirement for report and configuration printers for generating hard copy reports and providing configuration documentation is based on applicable sections of NUREG-0700 (O'Hara et al. 2002 [DIRS 170780]) and standard industry practice and is required to ensure adequate means to provide hard copy reports from the system.

4.6.1.4 System Power

Criteria—The system shall receive normal and UPS power from the site emergency power system. The DCMIS shall be capable of performing its intended functions during loss of normal power. The status monitoring of mechanical handling control equipment shall be available during loss of normal power.

Technical Rationale—The requirement for UPS power is as recommended by IEEE Std 1100-1999, *Recommended Practice for Powering and Grounding Electronic Equipment* [DIRS 158849], and standard industry practice. This criterion is required for surface and subsurface repository operations.

4.6.1.5 System Interfacing Criteria

Criteria—The system shall interface with other waste management systems. The interface to these systems shall be via an opened, non-proprietary network protocol. These interfaces shall be designed to the specifications of NEMA ICS 1-2000, *Industrial Control and Systems General Requirements* [DIRS 164223], and IEEE Std 802.3ah-2004 [DIRS 172990]. The system shall be able to interface with various offsite locations.

Technical Rationale—This criterion is required to monitor, control, and provide the necessary data exchange between systems within the facility and to offsite locations.

4.6.1.6

Criteria—Portions of the DCMIS and non-ITS process control systems that are required to operate after an earthquake shall be designed for the site-specific 1,000-year return period earthquake. The acceptability of passive equipment, such as cabinets and enclosures, shall be verified by analysis. Acceptability, including operability after an earthquake, for active equipment such as human machine interface consoles, controllers, and input/output modules, shall be verified in accordance with ANSI/IEEE Std 344-1987 (Reaffirmed 1993) [DIRS 159619], Section 9.

Technical Rationale—System equipment associated with important functions, such as post event monitoring, including transfer of information to the emergency operations center, controls necessary for plant stabilization after an off-normal event, controls necessary for emergency lighting, control of selected HVAC units, and monitoring and controls for worker industrial and life safety, should be designed to operate after an earthquake.

4.6.2 Radiation/Radiological Monitoring Design Criteria

4.6.2.1 Radiation/Radiological Monitoring Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Instrumentation and Control	Radiation/ Radiological Monitoring[b]	ANSI N320-1979, ANSI N42.17B-1989, ANSI N42.18-1980, ANSI/ANS-8.3-1997, ANSI/ANS-HPSSC-6.8.1-1981, ANSI/HPS N13.1-1999, ANSI/IEEE Std 344-1987 (Reaffirmed 1993), IEEE Std 1050-1996, NFPA 70-2004
		Regulatory Guide 1.180, Regulatory Guide 1.21, Regulatory Guide 3.71, Regulatory Guide 4.1, Regulatory Guide 8.25, Regulatory Guide 8.5, Regulatory Guide 8.8
		10 CFR Part 20
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the radiation/radiological monitoring (RRM) system. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing the CFR supports compliance with requirements in PRD-015/P-020, PRD-015/P-021, and PRD-015/P-015. Applicable sections of this document will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.6.2.2 Area Radiation Monitors

4.6.2.2.1

Criteria—Area radiation monitors (ARMs) shall be provided where required throughout the surface and subsurface facilities in areas that require entry or exit or both, which are normally accessible as required by ANSI/ANS-HPSSC-6.8.1-1981, *Location and Design criteria for Area Radiation Monitoring Systems for Light Water Nuclear Reactors* [DIRS 159434].

Technical Rationale—This criterion is required to ensure adequate coverage of areas where there is potential for significant personnel radiation dose.

4.6.2.2.2

Criteria—Each monitor shall have local exposure rate indication as well as audible and visual alarms as stated in ANSI/ANS-HPSSC-6.8.1-1981 [DIRS 159434].

Technical Rationale—This criterion is required to alert individuals in the vicinity of the monitor that immediate action is necessary to minimize exposure to gamma radiation and neutron radiation, if applicable.

4.6.2.2.3

Criteria—The ARMs shall be located where there is the potential for a sudden and significant change in radiation fields as stated in ANSI/ANS-HPSSC-6.8.1-1981 [DIRS 159434].

Technical Rationale—This criterion is required to provide workers with an indication that the working conditions have changed so they are able to react to the change appropriately.

4.6.2.2.4

Criteria—The monitors shall provide output signals representing radiation levels along with high-level and instrument fault alarms.

Technical Rationale—This criterion is required to provide the DCMIS CCCF with an indication that an abnormality or off-normal event has occurred in a specific or general area of the RRM system.

4.6.2.2.5

Criteria—Signals from each monitor shall be sent to a remote location per ANSI N320-1979 (Reaffirmed 1993), *Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation* [DIRS 166977].

Technical Rationale—This criterion is required to provide information to the DCMIS to characterize the type of release and initiate actions for evacuation and re-entry, if required. These data will also provide data for backup storage, trending, and performance confirmation.

4.6.2.2.6

Criteria—If the safety analysis during the hazard analysis review process determines that locks, keys, and administrative controls are not deemed sufficient, gamma interlock monitors shall be included as part of the annunciation and alarm system for shield doors and personnel shielded access doors. The monitors and control systems are engineered to fail to the alarm state (10 CFR Part 20, Energy: Standards for Protection Against Radiation [DIRS 173165]).

Technical Rationale—Monitors provide sufficient sensitivity to protect personnel. Status output signals are connected to the programmable protection system to provide status and alarm information in the DCMIS.

4.6.2.2.7

Criteria—ARMs shall be provided as required by 10 CFR Part 20 [DIRS 173165].

Technical Rationale—This criterion is required to ensure the adequate coverage of areas where radiation exposure shall be monitored and to meet performance requirements.

4.6.2.3 Continuous Air Monitors

4.6.2.3.1

Criteria—The continuous air monitors (CAMs) shall be located where there is a potential for intake of airborne radioactive materials by personnel as required by ANSI N42.17B-1989, *American National Standard Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation* [DIRS 164204].

Technical Rationale—This criterion ensures adequate coverage of areas where personnel exposure to airborne radioactivity is possible. This criterion also ensures that monitoring is performed for process systems that may contribute to radioactive effluent pathways or process systems that may be a precursor to an effluent pathway.

4.6.2.3.2

Criteria—Each monitor shall have local audible alarms with at least 75 dB in a frequency range of 500 to 3,000 Hz at a distance of 15 cm (6 in.) and flashing or steady state visual alarms as required by ANSI N42.17B-1989 [DIRS 164204]. Any alarming monitor should have a dB frequency range that considers the background noise in the working environment and be about 15 dB above the background, not to exceed 115 dB. The alarm should be distinctive and identifiable from other alarms used in the system.

Technical Rationale—This criterion is required to alert individuals in the vicinity of the monitor that immediate action is necessary to minimize exposure to airborne radioactivity.

4.6.2.3.3

Criteria—The monitors shall provide output signals representing airborne radioactivity levels along with high-level and instrument fault alarms as stated in ANSI N42.17B-1989 [DIRS 164204].

Technical Rationale—This criterion is required to provide the DCMIS CCCF with an indication that an abnormality or off-normal event has occurred in a specific or general area of the RRM CAM system, which may indicate a release of radioactivity to an effluent pathway.

4.6.2.3.4

Criteria—Signals from each monitor shall be sent to remote locations per ANSI N320-1979 [DIRS 166977].

Technical Rationale—This criterion is required to provide the information to the DCMIS to characterize the type of release and alert operators of the release. These data will also provide data for backup storage, trending, and performance confirmation.

4.6.2.3.5 Not Used

4.6.2.3.6

Criteria—CAMs shall compensate between background radiation and facility-generated radioactive material.

Technical Rationale—This criterion is required to ensure that the monitoring results reflect radioactivity from licensed material and not from background radiation per 10 CFR Part 20 [DIRS 173165].

4.6.2.4 Slave Alarm Units/Door Warning Signs

Criteria—Alarm units shall be provided to warn against the continued occupancy of radioactive areas due to high airborne radioactivity. Alarm driver units from one or more CAMs shall activate the slave alarm units, as required. Alarm driver units allow the interconnection of a number of CAMs and slave alarm units.

Door warning signs shall be provided to warn against entry into the radioactive areas, at access points around the radioactive area. Door warning signs shall be a standard design and include separate annunciation of high airborne radioactivity and high radiation. The door warning signs shall be activated from one or more CAM or ARM, as required.

The door warning signs shall include key-switch reset, which shall be located in readily accessible locations. The warning shall not automatically reset when the off-normal situation-initiating monitor returns to normal.

The door warning signs, alarm units, CAMS, and ARMS shall be powered from an UPS.

Technical Rationale—Alarms and warning signs warn of potential radiation exposures and help minimize the exposures.

4.6.2.5 Continuous Airborne Effluent Monitors

4.6.2.5.1

Criteria—The airborne radioactivity exhaust systems shall be provided on emplacement exhaust shafts and ventilation stacks of facilities identified for radioactive effluent pathways, due to normal operations and Category 1 event sequences. Airborne effluent radioactivity monitoring shall compensate between background radiation and facility-generated effluents. Sampling and monitoring shall be in accordance with applicable sections of ANSI/HPS N13.1-1999, *American National Standard Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities* [DIRS 152380].

Technical Rationale—This criterion is required to ensure the adequate monitoring of areas where airborne radioactivity is expected.

4.6.2.5.2

Criteria—The system shall sample the exhaust air for airborne radioactive particulate matter as required by 10 CFR Part 20 [DIRS 173165]; Regulatory Guide 1.21, *Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants* [DIRS 105991]; and Regulatory Guide 8.25, *Air Sampling in the Work Place* [DIRS 106172].

Technical Rationale—This criterion is required to ensure proper monitoring of radioactive air effluents and to meet performance and regulatory requirements.

4.6.2.5.3

Criteria—The continuous airborne effluent monitors shall have the capability to alarm at a preset level and on an instrument fault per ANSI N42.18-1980 (Reaffirmed 1991), *Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents* [DIRS 161832].

Technical Rationale—This criterion is required to provide the DCMIS CCCF with an indication that an abnormality or off-normal event has occurred in a specific or general area of the continuous airborne effluent monitors.

4.6.2.5.4

Criteria—Signals representing the airborne radioactivity level and status shall be input to the DCMIS to allow continuous airborne effluent monitor status to be remotely monitored per ANSI N42.18-1980 [DIRS 161832].

Technical Rationale—This criterion is required to collect and provide data to the DCMIS for backup storage, trending, and performance confirmation.

4.6.2.5.5

Criteria—Signals from individual radiation monitors shall be sent to a remote location per ANSI N42.18-1980 [DIRS 161832].

Technical Rationale—This criterion is required to provide the information to the DCMIS to characterize the type of release so adequate safety and administrative procedures can be followed.

4.6.2.5.6 Not Used

4.6.2.5.7 Not Used

4.6.2.6 Criticality Detection and Alarm

4.6.2.6.1

Criteria—Areas where fissile material is handled, stored, and packaged shall be evaluated for the provision of criticality detection and alarm features as a part of the RRM system. The design shall meet the requirements of ANSI/ANS-8.3-1997, *Criticality Accident Alarm System* [DIRS 103095], and the applicable guidance in Regulatory Guide 3.71, *Nuclear Criticality Safety Standards for Fuels and Material Facilities* [DIRS 103299] and Regulatory Guide 8.5, *Criticality and Other Interior Evacuation Signals* [DIRS 106074].

Technical Rationale—This criterion is required to ensure proper alerting and prompt evacuation of personnel so as to minimize radiation exposure if a criticality accident were to occur. Criticality detection and alarms are being provided as a defense in depth measure.

4.6.2.7 Alarm Annunciation System

4.6.2.7.1

Criteria—The alarm annunciation system shall normally indicate the status of, and locate problems with instruments within, the RRM system of the facility as required by ANSI N42.17B-1989 [DIRS 164204], ANSI N42.18-1980 [DIRS 161832], and ANSI/ANS 8.3-1997 [DIRS 103095].

Technical Rationale—This criterion is required to ensure the proper system operation and maintenance.

4.6.2.7.2

Criteria—An alarm annunciation system shall be provided locally and in the CCCF with the capability to monitor instrument parameters and provide alarm information for the following items per ANSI N320-1979 [DIRS 166977]:

- ARMs
- CAMs
- Stack effluent monitors
- Criticality detectors.

Technical Rationale—This criterion is required to alert the CCCF operator that immediate action is necessary to minimize personnel exposure and to meet performance requirements.

4.6.2.8 System Hardware

4.6.2.8.1

Criteria—The RRM system hardware shall include provisions for upgrades.

Technical Rationale—This criterion is required to increase the operational life of the system and support closure deferral, and it is a general engineering practice.

4.6.2.8.2

Criteria—The RRM system components shall provide self-test capabilities and performance diagnostics to verify the integrity and accuracy of the RRM data as required by ANSI N42.17B-1989 [DIRS 164204], ANSI N42.18-1980 [DIRS 161832], and ANSI/ANS 8.3-1997 [DIRS 103095].

Technical Rationale—This criterion is required to perform system maintenance and troubleshooting without affecting the performance of the system.

4.6.2.8.3

Criteria—The system components shall function normally if installed in radiation environments as required by ANSI N42.17B-1989 [DIRS 164204] and ANSI/ANS 8.3-1997 [DIRS 103095].

Technical Rationale—This criterion is required so that components susceptible to radiation can withstand and operate in their radiation environment.

4.6.2.8.4

Criteria—The monitors shall be periodically tested and calibrated in accordance with ANSI/ANS-HPSSC-6.8.1-1981 [DIRS 159434], ANSI N42.17B-1989 [DIRS 164204], and ANSI N42.18-1980 (Reaffirmed 1991) [DIRS 161832].

Technical Rationale—This criterion is to ensure the proper functioning of the equipment.

4.6.2.8.5

Criteria—The radiation monitoring equipment shall be installed to ensure adequate workspace will be of sufficient size to allow for servicing and maintenance per NFPA 70-2004 [DIRS 172711].

Technical Rationale—This criterion is to permit ready and safe operation and maintenance.

4.6.2.8.6

Criteria—The system components shall be located, shielded, or located and shielded to minimize exposure except for required radiation measuring components. This is in accordance with Regulatory Guide 8.8 [DIRS 103312].

Technical Rationale—This criterion is required to ensure that personnel exposure is minimized to meet ALARA principles.

4.6.2.8.7

Criteria—The system shall be designed and installed such that the effects of electromagnetic interference and radio-frequency interference will be minimized. This is in accordance with Regulatory Guide 1.180, *Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems* [DIRS 171818].

Technical Rationale—This criterion is required to ensure that instrumentation associated with this system will be protected from the effects of electromagnetic and radio-frequency interference.

4.6.2.9 System Power

Criteria—The system shall receive UPS power from the site emergency UPS power subsystem as required by ANSI N320-1979 [DIRS 166977].

Technical Rationale—This criterion is required so that the system is capable of performing its intended function during a loss of normal power or after the occurrence of Category 1 and Category 2 event sequences.

4.6.3 Environmental/Meteorological Design Criteria

4.6.3.1 Environmental/Meteorological Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Instrumentation and Control	Environmental/ Meteorological[b]	ANSI/ANS-3.11-2000, ANSI/IEEE Std 344-1987 (Reaffirmed 1993), IEEE Std 1289-1988, NEMA ICS 6-1993, NFPA 70-2004
		Regulatory Guide 1.12, Regulatory Guide 1.23, Regulatory Guide 8.8
		10 CFR Part 20
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the environmental/meteorological monitoring system. Applicable sections of these documents will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-002/T-012, and PRD-002/T-022. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.6.3.2 General

4.6.3.2.1

Criteria—The system shall provide alarms, operator messages, status indications, and trending through interface with the DCMIS. This is standard industry practice.

Technical Rationale—This criterion is required to provide operators in the CCCF with information that will inform them of system abnormalities or off-normal conditions.

4.6.3.2.2

Criteria—Equipment installed outdoors shall be designed for the expected environmental conditions. This is standard engineering practice.

Technical Rationale—This criterion is required to ensure that the equipment installed outdoors is designed to perform its intended functions in the expected environmental conditions.

4.6.3.2.3

Criteria—Removable or hinged parts of enclosures, such as doors and covers, shall be provided with a means for firmly securing them in place. This is in accordance with NEMA ICS 6-1993 (R 2001), *Industrial Control and Systems: Enclosures* [DIRS 164222].

Technical Rationale—This criterion is required to ensure that doors or covers are not inadvertently opened or removed; hence, exposing the electronics to any adverse weather conditions.

4.6.3.2.4

Criteria—Ergonomic considerations shall be included in the design and installation of the system. This is in accordance with IEEE Std 1289-1998, [DIRS 164225], Sections 5 and 6.

Technical Rationale—This criterion is required to facilitate ease of maintenance, reduce errors, and minimize health and safety risks.

4.6.3.2.5

Criteria—The system components shall be located, shielded, or located and shielded to minimize exposure. This is in accordance with Regulatory Guide 8.8 [DIRS 103312].

Technical Rationale—This criterion is required to ensure that personnel exposure is minimized to meet ALARA principles.

4.6.3.2.6

Criteria—The environmental/meteorlogical monitoring equipment shall be installed to ensure that the workspace will be of sufficient size to allow for servicing and maintenance per NFPA 70-2004 [DIRS 172711].

Technical Rationale—This criterion is to permit safe operation and maintenance.

4.6.3.3 Meteorological Monitoring

4.6.3.3.1

Criteria—The meteorological monitoring system shall provide data logging and storage of instantaneous values and 10-minute or 15-minute averages. These data shall be displayed continuously and in real-time. This is in accordance with ANSI/ANS-3.11-2000, *American National Standard for Determining Meteorological Information at Nuclear Facilities* [DIRS 151842].

Technical Rationale—This criterion is required to collect and provide data to users for real-time and historical analysis using an atmospheric dispersion model.

4.6.3.3.2

Criteria—The meteorological monitoring system shall provide data logging and storage locally that can be downloaded and uploaded to an appropriate computer for analysis. This is in accordance with ANSI/ANS-3.11-2000 [DIRS 151842].

Technical Rationale—This criterion is required so that if the data are not available from the DCMIS or meteorological server, it can be downloaded from local equipment.

4.6.3.3.3

Criteria—Power for the system shall be provided from a UPS, which is fed from the site normal electrical power systems, and solar cells with batteries for the remote equipment.

Technical Rationale—This criterion is required to maintain continuous operation and avoid extended data losses as required by ANSI/ANS-3.11-2000 [DIRS 151842].

4.6.3.3.4

Criteria—Functional checks of instrumentation shall be performed after exposure to extreme meteorological conditions or other events. This is in accordance with ANSI/ANS-3.11-2000 [DIRS 151842].

Technical Rationale—This criterion is required to ensure that the system integrity is not compromised.

4.6.3.3.5

Criteria—Minimum system and component accuracies shall be used from ANSI/ANS-3.11-2000 [DIRS 151842] and *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2003 [DIRS 163158]).

Technical Rationale—This criterion is required because the reference documents provide guidance regarding acceptable system and component accuracies.

4.6.3.3.6

Criteria—The datalogger shall be capable of sampling data at a rate of at least 30 samples within 60 seconds spaced equally over not less than 10 minutes. This is in accordance with ANSI/ANS-3.11-2000 [DIRS 151842].

Technical Rationale—This criterion is required because the reference document provides guidance regarding acceptable sample rates.

4.6.3.3.7

Criteria—The radio transceiver shall operate within the specified frequency range without interference.

Technical Rationale—This criterion is required to ensure that reliable data are transmitted to the meteorological server.

4.6.3.4 Seismic Monitoring

4.6.3.4.1

Criteria—The seismic monitoring system shall be operable at all times. This is in accordance with Regulatory Guide 1.12, *Nuclear Power Plant Instrumentation for Earthquakes* [DIRS 103170].

Technical Rationale—This criterion is required so that it can be determined whether the DBGM-1 has been exceeded.

4.6.3.4.2

Criteria—Power for the system shall be provided from a UPS, which is fed from the site normal electrical power systems.

Technical Rationale—This criterion is required to maintain continuous operation and avoid extended data losses as required by Regulatory Guide 1.12 [DIRS 103170].

4.6.3.4.3

Criteria—Sensors shall be protected against accidental impact. This is in accordance with Regulatory Guide 1.12 [DIRS 103170].

Technical Rationale—This criterion is required to prevent erroneous readings.

4.6.3.4.4

Criteria—The seismic motion analysis equipment shall be capable of sampling data at a rate of at least 200 samples per second. The bandwidth should be at least 0.20 Hz to 50 Hz. This is in accordance with Regulatory Guide 1.12 [DIRS 103170].

Technical Rationale—This criterion is required because the reference document provides guidance regarding acceptable sample rates.

4.6.3.5 Measurement Devices

4.6.3.5.1

Criteria—Sensors shall be installed to measure wind speed, wind direction, pressure, relative humidity, temperature, solar radiation, and precipitation within site boundaries. This is in accordance with Regulatory Guide 1.23, *Onsite Meteorological Programs* [DIRS 103640].

Technical Rationale—This criterion is required to monitor meteorological conditions, which will be used as an aid in the evaluation of radiological releases.

4.6.3.5.2

Criteria—Seismic sensors and recording devices shall be provided within the site boundary so that all significant ground motion associated with an earthquake is recorded. This is in accordance with Regulatory Guide 1.12 [DIRS 103170].

Technical Rationale—This criterion is required for historical analysis and to measure and record ground motion to determine whether the operational basis earthquake has been exceeded.

4.6.3.5.3

Criteria—Seismic sensors shall measure vertical and horizontal peak acceleration (g) with a range of 0 to 2 g and a frequency of 0.2 to 50 Hz. This is in accordance with Regulatory Guide 1.12 [DIRS 103170].

Technical Rationale—This criterion is required to ensure that the sensors adequately measure the expected maximum ground motion.

4.6.4 General Instrumentation Design Criteria

4.6.4.1 General Instrumentation Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Instrumentation and Control	General Instrumentation[b]	ACGIH 2005, ANSI/ANS-57.9-1992, ANSI/ISA-5.1-1984 (R1992), ANSI/ISA-50.00.01-1975 (R2002), ANSI/ISA-S51.1-1979 (R1993) (R1995), ANSI/ISA-S7.0.01 1996, API Std 526, ASME 2004 (Sections I and VIII), ASME B16.34-1996, ASME B16.34a-1998, ASME B31.1-2001, ASME B31.3-2002, ASME MFC-3M-1989, ASME MFC-8M-2001, ASME PTC 19.3-1974, IEEE Std 208-1995, ISA-MC96.1-1982, ISA-RP16.1,2,3-1959, ISA-RP16.5-1961, ISA-RP16.6-1961, ISA-RP31.1-1977, NEMA ICS 6-1993 (R2001), NFPA 497-2004, NFPA 70-2004, NFPA 75-2003
		Regulatory Guide 8.8
		None
		DOE O 440.1A

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]). Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This regulatory guide has been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide.

[3] None.

[4] The listed DOE directive supports compliance with requirements of PRD-018/P-019. Applicable sections of this DOE directive will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.6.4.2 General

4.6.4.2.1 Units of Measurement

Criteria—The units of measure to be used for this section shall be the United States customary units shown in Table 4.6.4-1.

Table 4.6.4-1. Units of Measurement

Parameter	Preferred Units[a]
Mass	lb, ton (defined as a short ton of 2,000 lbs)
Length	ft, in.
Volume (volume, liquid)	ft^3 (gal)
Positive gauge pressure	psig
Vacuum	bars absolute, torr
Absolute pressure	In. H_2O or psia
Differential pressure	In. H_2O, mm Hg, or psid
Temperature	°F, °C
Flow (solids)	tons/hr, lb/hr
Flow (liquids)	gpm
Flow (gas)	cfm, scfm
Flow (steam or slurries)	lb/hr
Level	in., ft, or % (for tank levels)
Density	lb/ft^3
Velocity	fps
Composition	%wt, %vol, or ppm
Radiation	rad/hr, rem/hr
Activity	ci
Electrical current	ampere
Electrical potential	volt
Resistance	ohm
Power	hp, BTU/hr
Viscosity	cp
Conductivity	siemens

NOTE: [a] Where appropriate, the above may be modified by the following prefixes:

Multiplication Factor	Prefix	Symbol
10^6	mega	M
10^3	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ

Technical Rationale—All transmitters, gauges, and other readouts for this facility shall be calibrated in English units per the table above.

4.6.4.2.2

Criteria—Cabinets, racks, and systems that utilize identical components shall be standardized to reduce maintenance and warehousing activities. Components performing similar duties shall be standardized, as far as possible, so that one particular make, model, and size can be used in all similar applications. Where possible, commercially available items without modification shall be selected from the manufacturer's standard range.

Technical Rationale—The goals of this effort are to reduce procurement costs, spares holdings, and design effort, while fostering increased operability and maintainability.

4.6.4.2.3

Criteria—A process and mechanical handling monitoring CCTV system shall be provided. The CCTV system is a system of the communications system. The CCTV video is integrated with the DCMIS. Areas are classified according to their respective hazard, with electrical and instrumentation and control equipment, specification, design, and installation engineered appropriately in accordance with the guidelines of NFPA 70-2004 [DIRS 172711]; NFPA 497-2004, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* [DIRS 173514]; and IEEE Std 208-1995, *IEEE Standard on Video Techniques: Measurement of Resolution of Camera Systems-1993 Techniques* [DIRS 164228].

Technical Rationale—A closed circuit television system is required for the remote viewing of equipment and operations in areas where the radiation levels are too high for personnel access.

4.6.4.2.4

Criteria—Transmitted signals to and from the field shall be 4 to 20 mA where continuous analog current signals are used. Digital pulses or optic transmissions are acceptable where appropriate. Signal levels within vendor instrument systems shall be as specified by the vendor and approved by BSC.

Technical Rationale—The output signal of 4-20 mA for instrumentation transmitters is a well-known industry standard, which is a commonly accepted industry practice per ANSI/ISA-50.00.01-1975 (R2002), *Compatibility of Analog Signals for Electrical Industrial Process Instruments* [DIRS 164191], Section 3.0.

4.6.4.2.5

Criteria—Instrument ranges shall be selected to preclude damage during startup or expected abnormal operating conditions.

Technical Rationale—Minimum, maximum, and normal process operating conditions are used to establish the basis for the sizing and selection of instruments per ANSI/ISA-50.00.01-1975 (R2002) [DIRS 164191], Section 2.0.

4.6.4.2.6

Criteria—Pressure and flow transmitters shall be supplied with valve manifolds.

Technical Rationale—Manifolds are normally used for ease of operation, maintenance, and calibration of the instrument and is standard for industry.

4.6.4.2.7

Criteria—Instrument enclosures shall be per NEMA ICS 6-1993 (2001) [DIRS 164222]. The minimum acceptable standard of protection against liquids and solids ingress for indoor and outdoor mounted equipment shall be NEMA 4 or 4X, as appropriate. Indoor service enclosures not subject to potential liquid or solids ingress shall be NEMA 12. NEMA 1 enclosures are acceptable for equipment located in rooms with HVAC.

Technical Rationale—Proper enclosure selection for instruments protects them from corrosive environments and hostile weather conditions.

4.6.4.2.8

Criteria—Instrumentation requiring winterization for protection against the cold shall be installed within thermally insulated enclosures provided with a heater and thermostat. When temperature upper limits are expected to be exceeded due to heat, air-conditioning shall be provided.

Technical Rationale—Winterization or trace heating and air-conditioning are the industry standard means of weather protection used for instruments that may become inoperable due to freezing or crystal precipitation and overheat, respectively.

4.6.4.2.9

Criteria—Instrument grade air shall be provided that is oil free, dry, and filtered at a minimum of 100 psig. Instrument air shall be dried in accordance with the criteria identified in Sections 4.8.5.4.4 and 4.8.5.4.5.

Technical Rationale—*Quality Standard for Instrument Air* (ANSI/ISA-S7.0.01-1996 [DIRS 164287]) establishes standard air supply pressure and operating ranges for pneumatic devices, provides limits for moisture and oil content, and entrained particle size in instrument quality air.

4.6.4.2.10

Not used.

4.6.4.2.11

Criteria—All field mounted controllers, control valves, and transmitters (except for line mounted flow transmitters) shall be easily accessible from grade or platform. Local indicators, such as pressure gauges, flow indicators, and gauge glasses shall be accessible and readable from the grade or operating level and, if used for manual control, shall be readable at the control device.

Technical Rationale—Consideration of instrument accessibility in design would ease the control, operation, and maintenance of any system.

4.6.4.2.12

Criteria—All design, installation, and wiring of instrument systems shall be in accordance with the applicable sections of the following codes and standards:

- ANSI/ANS 57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)* [DIRS 103093].
- NFPA 70-2004, *National Electrical Code* [DIRS 172711].
- NFPA 75-2003, *Standard for the Protection of Information Technology Equipment* [DIRS 167085].
- ANSI/ISA-5.1-1-1984 (R1992), *Instrumentation Symbols and Identification* [DIRS 166742].

These codes and standards are not meant to be all-inclusive; other codes and standards may apply.

Technical Rationale—The codes and standards cited are commonly used in industry.

4.6.4.2.13

Criteria—Instrumentation shall be located, arranged, and shielded as required to minimize radiation exposure to personnel during operation and maintenance. This is in accordance with Regulatory Guide 8.8 [DIRS 103312].

Technical Rationale—This criterion is required to ensure compliance with ALARA principles.

4.6.4.3 Temperature Measurement

4.6.4.3.1

Criteria—Remote temperature measurement shall be primarily made by the use of either: resistance temperature detectors (RTDs) or thermocouples. Temperature transmitters may be provided with RTDs and thermocouples. Wherever possible, these devices shall be used with head mounted 4-20 mA output, smart transmitters.

Technical Rationale—Use of RTDs and thermocouples is commonly used throughout the industry.

4.6.4.3.2

Criteria—Dual RTDs or thermocouple elements shall be provided.

Technical Rationale—This criterion provides a backup element in the event of an instrument failure thereby reducing downtime. It also provides a second element that is available for troubleshooting and testing.

4.6.4.3.3 RTDs

Criteria—RTDs shall use duplex element, 3 wire, 100 Ω platinum with DIN type and α coefficient 0.00392 Ω/Ω-F. Each element head shall have two cable entries (one plugged). The RTDs shall be of spring-loaded, tip-sensitive construction.

Technical Rationale—100Ω platinum 3 wire elements have become an increasingly popular standard for use in industrial applications because of their increased accuracy. They are widely used in HVAC, electric motors, process control, and electronic circuits.

4.6.4.3.4 Thermocouples

Criteria—Thermocouples shall be selected to meet the requirements of the application. Type J (-346 to 1,400°F) and type K (-454 to 2,502°F) calibration thermocouples shall be used as standard.

Technical Rationale—Thermocouples are the most commonly used method of industrial temperature measurement in the United States. Thermocouples are listed in ISA-MC96.1 1982, *Temperature Measurement Thermocouples* [DIRS 164231]. They are characterized by their low cost and wide rangeability.

4.6.4.3.5 Temperature Controllers

Criteria—Where local temperature control is required, liquid or gas filled type-indicating transmitters may be used. Combined transmitter/controllers may be used for simple services such as tank heating. Transmitter element shall be of the bulb type.

Technical Rationale—Local temperature controllers are still considered the traditional and most economical choice in projects where sensitive electronics are not required.

4.6.4.3.6 Temperature Gauges

Criteria—Bimetallic thermometers shall be used for temperature gauges. Temperature elements shall be installed in thermowells. Filled-system (liquid or gas) type indicating thermometers shall be considered as appropriate.

Technical Rationale—The use of a bimetal, gas, or vapor-actuated thermometer in the industry is common practice where the need arises to make temperature measurements that can be observed on the spot or locally and where errors in excess of one percent of span are acceptable.

4.6.4.3.7 Thermowells

Criteria—A thermowell shall be provided for temperature sensing elements. Thermowells shall be assessed for resonance effects. Where thermowells are installed in lines subject to high fluid velocities, combined stress and frequency calculations shall be carried out to a proven method. The vortex frequency, where calculated, shall be to ASME PTC 19.3-1974, *Part 3, Temperature Measurement, Instruments and Apparatus, Supplement to ASME Performance Test Codes* [DIRS 167090].

Technical Rationale—Thermowells are provided for protection of the temperature elements and are commonly used throughout the industry.

4.6.4.4 Flow Measurement

4.6.4.4.1 Flow Measuring Devices

4.6.4.4.1.1

Criteria—The appropriate flow measurement shall generally be made by one of the following devices: differential pressure flowmeters, positive displacement flowmeters, turbine flowmeters, variable area flowmeters, or open channel flowmeters.

Technical Rationale—Each type of flowmeter has its own specific advantages and limitations, and all features are accepted in the industry as best for the particular application.

4.6.4.4.1.2

Criteria—Other flow measurement methods shall be considered such as magnetic flowmeters, mass flowmeters (coriolis), oscillatory flowmeters, target flowmeters, and ultrasonic flowmeters.

Technical Rationale—Such instruments shall be used where the benefits of increased accuracy or simplicity of installation justify the higher cost.

4.6.4.4.1.3

Criteria—Differential pressure transmitters measure the differential pressure and provide the signal that is converted to the actual flow value per ASME MFC-8M-2001, *Fluid Flow in Closed Conduits: Connections for Pressure Signal Transmissions Between Primary and Secondary Devices* [DIRS 167093]. Primary elements in differential pressure flowmeters shall be selected from the following types: orifice plate, venturi, flow nozzle, flow tube, pitot tube, wedge, v-cone, elbow, and laminar.

Technical Rationale—The most frequently used primary element in differential pressure type flowmeters is the orifice plate. The orifice plate is the most economical and is simply a flat piece of metal with a specific-sized hole bored in it. This is commonly specified in industry standards and used by engineering, procurement, and construction companies.

4.6.4.4.2 Orifice Plate

4.6.4.4.2.1

Criteria—Orifice plates shall normally be installed between line-sized orifice flanges equipped with flange taps. The d/D, or beta ratio, should normally be between 0.2 and 0.7 per ASME MFC-3M-1989, *Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi* [DIRS 167092].

Technical Rationale—The beta ratio of 0.2 to 0.7 is a commonly used standard for differential orifice plate measurement. Ratios below 0.2 are not recommended because of pressure loss. Ratios above 0.7 are not recommended because of the reduction in differential pressure.

4.6.4.4.2.2

Criteria—Orifice plates shall be thin, square edged, paddle type, faced, and recessed and, unless otherwise specified, shall be fabricated of Type 316 stainless steel as a minimum. The following data shall be stamped on the upstream side of the tab projecting beyond the orifice flanges: upstream, instrument tag number, plate material, orifice diameter, and pipe inside diameter.

Technical Rationale—This practice in the industry makes the identification and replacement of existing orifices easier per ASME MFC-3M [DIRS 167092].

4.6.4.4.3 Meter Runs

4.6.4.4.3.1

Criteria—Meter runs shall be based on a beta ratio of 0.7. The minimum meter run diameter shall be 2 in. Where it is impossible to provide the required meter run lengths, straightening vanes may be used per ASME MFC-3M [DIRS 167092].

Technical Rationale—The intent of this specification is to allow a fluid velocity profile to fully develop before it is metered.

4.6.4.4.3.2 Meter Ranges

Criteria—Differential type flow transmitters shall normally be used for cases where remote flow control is desired. The range specified shall normally be 100 in. of water column, although higher or lower ranges shall be used to obtain a beta ratio within the specified limits of 0.2 and 0.7.

Technical Rationale—Flow transmitters with 100 in. of water column are routinely used for good rangeability because it gives room for adjustment to a lower or increased water maximum pressure differential when a change in process condition warrants a corresponding change in transmitter range.

4.6.4.4.3.3 Sizing and Ranging Requirements

Criteria—Flow calculations shall use 20 percent above the maximum design flowrate as the meter maximum. All transmitters may be used to the manufacturers maximum recommended turndown to a ratio not exceeding 40:1. Flow rate turndown for an orifice plate with a transmitter shall not be greater than 3:1; those fitted with two transmitters shall not be greater than 10:1.

Technical Rationale—These ranges have been found to be the ideal limits to use in the industry and still remain within the normally required accuracy for the flow instruments. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

4.6.4.4.4 Variable Area Flowmeters

Criteria—Rotameters shall be an armored type with a magnetic pick-up. Mechanically protected glass tube meters may be used on non-hazardous fluid services. Rotameters shall be per the following standards:

- ISA-RP16.1, 2, 3-1959, *Terminology, Dimensions and Safety Practices for Indicating Variable Area Meters (Rotameters)—RP16.1 Glass Tube, RP16.2 Metal Tube, RP16.3 Extension-Type Glass Tube* [DIRS 167089].
- ISA-RP16.5-1961, *Installation, Operation, and Maintenance Instructions for Glass Tube Variable Area Meters (Rotameters)* [DIRS 167088].
- ISA-RP16.6-1961, *Methods and Equipment for Calibration of Variable Area Meters (Rotameters)* [DIRS 167087].

Technical Rationale—Where process fluid conditions prohibit the use of orifice plates, rotameters may be used in lines one-half inches to three inches. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

4.6.4.4.5 Turbine Meters and Positive Displacement Meters

Criteria—Turbine meters and positive displacement meters shall have a properly sized strainer installed upstream of the meter and shall have provisions to assure elimination of vapors from and prevent formation of vapors in the meter body. Block and vent valve or bypass arrangements shall be provided to eliminate vapors per ISA-RP31.1-1977, *Specification, Installation, and Calibration of Turbine Flowmeters* [DIRS 169812].

Technical Rationale—Turbine and positive displacement meters shall be used where higher accuracy of flow measurement is required.

4.6.4.5 Level Measurement

4.6.4.5.1 General

Criteria—The appropriate level measurement shall generally be made by one of the following techniques: float type (displacer, ball), radar, hydrostatic head (static, bubbler system, differential pressure), capacitance, conductivity, sonic, and ultrasonic.

Technical Rationale—The indication of level serves as a measure of the inventory in the vessel. The approach to level measurement is to determine whether a float, a displacer, or some equivalently simple technology may be applicable. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

4.6.4.5.2 Gauge Glass

Criteria—The visibility of the level glass shall be specified such that the glass covers the operating range of the level instrument. In alarm and shutdown service, the visibility shall normally cover the range of all instruments, including the shutdown set points. All gauge glass shall have a rating equal to or higher than the vessel/equipment design pressure and temperature. Gauge glasses shall be reflex type for all services except the following where transparent type, with illuminators, shall be used: (1) interface between liquids, (2) dirty or dark-colored liquids, and (3) liquids requiring protecting shields, such as steam condensate above 300 psig or caustic above 15 percent. Frost shields shall be used if the operating temperature is below -7°C (20°F). This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

Technical Rationale—The gauge glass criteria stated above is a typical industry standard for checking the accuracy and operational condition of level instruments.

4.6.4.5.3 Magnetic Level Gauge

Criteria—Magnetic type level gauges shall be used where glass breakage would be a hazard or when measuring dangerous or toxic fluids. Magnetic type level gauges shall be used only in areas that are free of the physical forces/materials that would adversely affect the magnetic operation of the system.

Technical Rationale—Magnetic type gauges are used for services in which gauge glasses are not suitable for the application.

4.6.4.6 Pressure Measurement

4.6.4.6.1

Criteria—Pressure measurement shall normally be made by the use of electronic pressure and differential pressure transmitters. Where necessary, drain valves shall be installed at the lowest point in each gas-containing line to facilitate moisture removal. A block and bleed instrument valve (manifold) shall be provided between the primary valve and pressure instrument. Process wetted transmitters, such as pressure transmitters, shall be located in shielded locations. For low activity waste, the requirement for pressure transmitters to be housed within shielded enclosures shall be evaluated based on ALARA principles.

Technical Rationale—Transmitters used in radioactive service are designed for radiation tolerance.

4.6.4.6.2

Criteria—Pressure elements shall be Type 316 stainless steel as a minimum unless process conditions require a different material. Pulsation dampeners shall be furnished on all pressure transmitters in vibrating or pulsating services. Pressure instruments in steam or other high temperature vapor service shall be protected by a liquid seal. Pressure instruments in services that are corrosive to available pressure elements or where plugging may occur shall be furnished with clean-out type filled diaphragm seals.

Technical Rationale—These available accessories may be used in conjunction with pressure instruments to improve their ability to withstand adverse environmental conditions and to broaden their usefulness.

4.6.4.6.3 Pressure Gauges

Criteria—Accuracy of direct connected gauges in process service shall be at least 0.5 percent of maximum scale reading over the entire scale. Maximum operating temperature and pressure must be less than the rating of the gauge. The range shall be specified so that the gauge operates in the middle third of the scale. Normally, the maximum operating pressure should not exceed 75 percent of the full-scale range. Over pressure protection shall be 1.3 times the maximum rating to prevent set or loss of calibration from continuous over pressures. Dials shall normally be 4-1/2 in. diameter with a white face with black markings. Pressure gauges in pulsating services shall be equipped with an integrally mounted dampening mechanism and shall have filled cases. Siphons shall be used to prevent steam or other condensable vapors from entering the pressure gauge.

Technical Rationale—The criteria listed above are an accepted industry standard for good practice in specifying pressure gauges.

4.6.4.7 Density Measurement

Criteria—Density measurement shall generally be made by one of the following methods: hydraulic head (bubbler), coriolis, refractometer, radiation (gamma ray densitometer), gravitometer, buoyancy, or fixed volume weighing.

Technical Rationale—The bubbler system and coriolis are the two most widely used methods for density measurement. The bubbler system is for mounting directly in the vessel and is considered the simplest, most inexpensive, and relatively fast method, whereas the coriolis is used for in-line density measurement of almost any type of fluid streams. The criteria listed above are an accepted industry standard for good practice in specifying density instruments.

4.6.4.8 Control Valves

4.6.4.8.1 Valve Styles and Characteristics

Criteria—Control valves shall generally be globe type. Where tight shutoff is required, single seated globe or cage trim valves shall be used. V-ball may be used for larger turndown, large capacities, tight shutoff, and dirty service. Butterfly valves may be used for high capacity and low-pressure drop service.

Technical Rationale—Consideration of cost, flow capacity, size, reliability, accuracy, and turndown (minimum controllable Cv) in selecting the best control valve for a given application will contribute to a good system performance (ANSI/ISA-S51.1-1979 (R1993) (R1995), *Process Instrumentation Technology* [DIRS 164220]).

4.6.4.8.2 Sizing

Criteria—Generally, valves shall be selected to have 1.4 times the Cv required for the normal design flow or 1.1 times the Cv required for the maximum design flow, whichever is the greater. Necessary modification of these general sizing criteria due to other design considerations shall be approved by BSC. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

Technical Rationale—This specified method in assigning the required control valve Cv for use in process design, piping system, and control valve sizing calculations ensures that every control valve is specified with the minimum design pressure drop required for energy conservation but still high enough for adequate control of the process. Experience indicates that a chronic contributor to loop instability is the selection of the wrong size valve.

4.6.4.8.3 Components

Criteria—Valve components and materials shall be suitable for the specified environmental and service conditions.

Technical Rationale—Particular attention is given to ideal valve component specifications in order to achieve long-term service of the control valve subjected to any given conditions.

4.6.4.8.4 Construction

Criteria—Valve design, body pressure, temperature rating, and minimum wall thickness shall comply with ASME B16.34-1996, *Valves-Flanged Threaded, and Welding End* [DIRS 165903] and ASME B16.34a-1998, *Addenda to ASME B16.34-1996, Valves-Flanged, Threaded, and Welding End* [DIRS 165266]. The minimum body and flange pressure rating for control valves, up to and including 6 in., shall be 300 ANSI. Above 6 in., butterfly valves shall have the line rating; rotary valves may be flangeless; and globe valves, including angle globe bodies, shall have a minimum rating of 300 ANSI. All flanged valves shall have flanges integral with the body. Slip-on flanges are not acceptable.

Technical Rationale—Proper consideration of control valve construction during the selection process helps prolong valve life.

4.6.4.8.5 Actuator

4.6.4.8.5.1

Criteria—Spring-diaphragm type actuators shall be used for throttling service unless use of piston type is justified by high torque requirements. Actuators shall be sized to provide sufficient power to stroke the valve through its full travel at 1.25 times the maximum pressure drop condition specified for the particular valve.

Technical Rationale—Proper selection of actuator for the valve will help improve valve stroking speed and valve stability.

4.6.4.8.5.2

Criteria—Fail-safe considerations shall be applied to each control valve application. Special accessories, such as air tanks and lock-up valves, shall be provided as required. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

Technical Rationale—These are special elements added to the control valve to ensure that it achieves the desired optimum performance during off-normal occurrences.

4.6.4.8.6 Noise

Criteria—The permitted maximum noise level measured at 3 ft from the control valve body shall be 85 dB(A). Noise levels greater than 85 dB(A) must be approved by the buyer.

Technical Rationale—Noise level shall conform to *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices* (ACGIH 2005 [DIRS 173218]), as required by DOE O 440.1A-1998, *Worker Protection Management for DOE Federal and Contractor Employees* [DIRS 102288].

4.6.4.9 Relief Valves

Criteria—The following general guidelines shall be used for the selection and specification of relief valves.

4.6.4.9.1 General

The different types of relief valves to use depending on the service are the following:

- Conventional spring opposed relief valves
- Pressure balanced relief valves
- Thermal expansion relief valves
- Screwed type relief valves.

4.6.4.9.2 Performance Requirement

- Sizing—Seller shall size and confirm the tentative sizing, provide all calculations, and meet code requirements.

- Rated Valve Capacity—Seller shall furnish the rated capacity of the relief valves for inclusion in a datasheet as calculated in accordance with *2004 ASME Boiler and Pressure Vessel Code* (ASME 2004 [DIRS 171846], Section I, Paragraph PG-70; Section VIII, Paragraph UG-131). The allowable overpressure taken for this calculation shall be based on the allowable overpressure stated in the datasheet for the following applicable codes:

  – ASME 2004 [DIRS 171846], Section I, Power Boilers.

  – ASME 2004 [DIRS 171846], Section VIII, Unfired Pressure Vessels.

  – ASME B31.1-2001, Power Piping [DIRS 158914].

  – ASME B31.3-2002, Process Piping [DIRS 158915]

- Pressure Setting—Seller shall set and certify the set pressure of the relief valves and advise the cold differential test pressure.

- Blowdown shall be less than 2 psig for valves with a set pressure of 100 psig. The minimum blowdown setting for higher set pressures shall not be less than 2 percent of the valve set pressure.

- Pressure—Temperature ratings shall be per API Std 526, *American Petroleum Institute, Flanged Steel Safety Relief Valves* [DIRS 164268].

4.6.4.9.3 Components

- Materials for bodies shall be per API Std 526 [DIRS 164268], Table 2-15.

- Bonnets shall use the same material as the body of the valve. Bolted bonnet for flanged relief valves are required. Closed bonnet (i.e., no vent anywhere in the bonnet) construction is required for all services except for power boilers service, per ASME 2004 [DIRS 171846], Section I. The conventional type valve shall have a bonnet vent plugged with an NPT plug. A bellows type relief valve shall have open bonnet vent with a bug screen or piped to a safe location.

- Screwed caps shall be used for all valves without lifting levers. Valves with plain lifting levers shall use plain caps secured with setscrews. Valves with packed levers shall use bolted caps providing the valve with a means of inserting a sealing wire to prevent the removal of cap.

4.6.4.9.4 Accessories

- Lifting Levers—ASME 2004 [DIRS 171846], Section I relief valves shall use lifting levers. ASME 2004 [DIRS 171846], Section VIII relief valves do not require lifting levers but are required for relief valves used in steam, hot water over 140°F, or air service unless specified otherwise.

- O-Ring (Soft) Seats—Must be compatible with the process fluid and temperature requirements.

Technical Rationale—These specifications are applicable to relieving devices operating on equipment where the pressure is in excess of 15 psig.

4.6.5 Important to Safety (ITS) Controls

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Instrumentation and Control	General Instrumentation[b]	ANSI/IEEE Std 1008-1987, ANSI/IEEE Std 1042-1987, ANSI/IEEE Std 336-1985, ANSI/IEEE Std 338-1987, ANSI/IEEE Std 344-1987 (Reaffirmed 1993), ANSI/ISA 67.04.01-2000, IEEE 1012-1998, IEEE 1028-1997, IEEE Std 1050-1996, IEEE Std 1074-1997, IEEE Std 323™-2003, IEEE Std 379-2000, IEEE Std 384-1992, IEEE Std 603-1998, IEEE Std 7-4.3.2™-2003, IEEE Std 828-1998, IEEE Std 829-1998, IEEE Std 830-1998
		Regulatory Guide 1.100, Regulatory Guide 1.105, Regulatory Guide 1.152, Regulatory Guide 1.153, Regulatory Guide 1.168, Regulatory Guide 1.169, Regulatory Guide 1.170, Regulatory Guide 1.171, Regulatory Guide 1.172, Regulatory Guide 1.173, Regulatory Guide 1.180, Regulatory Guide 1.53, Regulatory Guide 1.89, Regulatory Guide 8.8
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]). Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.6.5.1 Equipment Qualification

Criteria—The qualifications of instrumentation and controls equipment shall be in accordance with IEEE Std 323™-2003 [DIRS 166907]. The equipment qualification includes environmental and seismic qualification.

Technical Rationale—The equipment will be qualified to meet system performance requirements to prevent significant release of radioactive material to the environment during normal and abnormal service conditions and postulated event sequences.

4.6.5.2 ITS Control Systems

Criteria—The design of ITS control systems shall meet the requirements of IEEE Std 603-1998, *IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations* [DIRS 125916].

Technical Rationale—These standards establish the minimum functional and design requirements for an ITS system.

4.6.5.3 Common Cause Failure Prevention

Criteria—ITS control systems shall ensure its safety function or fail-safe in the event of a common cause failure per IEEE Std 379-2000, *IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems* [DIRS 166688].

Technical Rationale—This standard provides guidance to ensure no single common cause failure will cause an ITS control system to fail to perform its function.

4.6.5.4 ITS Programmable Logic Controllers

Criteria—The design of ITS programmable logic controllers shall meet the requirements of IEEE Std 7-4.3.2™-2003, *IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations* [DIRS 170777].

Technical Rationale—This standard establishes the minimum functional and design requirements for computers used as components in an ITS system, including requiring software verification and validation.

4.6.5.5 Seismic Requirements

Criteria—The seismic qualification of ITS control systems required to operate after a seismic event shall be in accordance with ANSI/IEEE Std 344-1987 (Reaffirmed 1993) [DIRS 159619].

Technical Rationale—This standard sets the procedures to establish that the ITS equipment will function after an earthquake.

4.6.5.6 Electrical Isolation

Criteria—Interfacing of ITS control systems to non-ITS systems shall be in accordance with IEEE Std 603-1998 [DIRS 125916], which endorses IEEE Std 384-1992 [DIRS 103105].

Technical Rationale—Electrical isolation between ITS and non-ITS system ensures the ITS system will continue to operate even if the non-ITS system fails.

4.6.5.7 Grounding

Criteria—ITS control equipment shall be grounded in accordance with IEEE Std 1050-1996 [DIRS 169773].

Technical Rationale—This standard ensures the equipment is properly grounded for personnel protection as well as providing suitable electrical noise immunity.

4.6.5.8 Setpoints

Criteria—Setpoints for ITS control systems shall be determined in accordance with ANSI/ISA 67.04.01-2000, *Setpoints for Nuclear Safety-Related Instrumentation* [DIRS 164201].

Technical Rationale—This standard ensures that errors in the channel for the process are included in the determination of the setpoints; thus, ITS control systems shall maintain control within established limits.

4.6.5.9 Software Development

Criteria—ITS control system software development shall follow IEEE Std 828-1998, *IEEE Standard for Software Configuration Management Plans* [DIRS 145986]; ANSI/IEEE Std 1042-1987, *IEEE Guide to Software Configuration Management* [DIRS 103098]; IEEE Std 1074-1997, *IEEE Standard for Developing Software Life Cycle Processes* [DIRS 169768]; IEEE Std 830-1998. *IEEE Recommended Practice for Software Requirements Specifications* [DIRS 125747]; IEEE Std 829-1998, *IEEE Standard for Software Test Documentation* [DIRS 145988]; and ANSI/IEEE Std 1008-1987, *IEEE Standard for Software Unit Testing* [DIRS 103101].

Technical Rationale—These standards ensure software development will achieve high functional reliability and design quality during development and testing.

4.6.5.10 Software Testing

Criteria—Testing and validation of software for ITS programmable logic controllers shall be performed in accordance with IEEE 1012-1998, *IEEE Standard for Software Verification and Validation Plans* [DIRS 103113] and IEEE 1028-1997, *IEEE Standard for Software Reviews* [DIRS 103112].

Technical Rationale—These standards establish a common framework to confirm the software satisfies its intended use and user needs. The assessments include the operational environment, hardware, interfacing software, operations, and users.

4.6.5.11 Periodic Testing

Criteria—ITS control systems shall operate on a continuous basis. ITS control systems shall provide status and alarm information to the DCMIS. Periodic testing of ITS control systems and instrumentation shall be in accordance with ANSI/IEEE Std 338-1987, *IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems* [DIRS 164253].

Technical Rationale—Functional tests and checks and calibration verification of ITS systems verify the safety systems shall perform their defined safety functions.

4.6.5.12 Installation Testing

Criteria—ITS control systems shall be installed and tested following ANSI/IEEE Std 336-1985, *IEEE Standard Installation, Inspection, and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities* [DIRS 171655].

Technical Rationale—Meeting the requirements for installation, inspection, and startup testing will ensure that ITS systems will perform its defined safety functions.

4.6.5.13 Electromagnetic and Radio-Frequency Interference

Criteria—All wireless communications shall meet conventional EMC standards to prevent interference with safety-related instrumentation and control systems.

Technical Rationale—Design and installation practices must mitigate and minimize the effects of electromagnetic interference and RFI in accordance with Regulatory Guide 1.180 [DIRS 171818].

4.7 MECHANICAL HANDLING

4.7.1 Mechanical Handling Design Criteria

4.7.1.1 Mechanical Handling Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Mechanical Handling	Mechanical Handling[b]	AAR 2004, AAR Standard S-2043, 2003, AISC 1997, ANSI N14.6-1993, ANSI/AISC N690-1994, ANSI/ANS-57.1-1992, ANSI/ANS-57.2-1983, ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/AWS D14.1-97-1998, ASCE 4-98, ASME 2004 (Section III, Division I, Subsection NE, Class MC Components), ASME B30.10-1999, ASME B30.16-2003, ASME B30.2-2001, ASME B30.20-2003, ASME B30.5a-2002, ASME B30.9-2003, ASME NOG-1-2002, ASTM C992-89 (Reapproved 1997), AWS D1.1/D1.1M:2002, AWS D1.6:1999, CMAA-70-2000, CMAA-74-2000, SAE J1078 (Reaffirmed APR94)
		NUREG-0554 (NRC 1979), NUREG-0612 (NRC 1980), NUREG-0700 (O'Hara et al. 2002), NUREG/CR-6407 (McConnell et al. 1996), Regulatory Guide 8.8
		10 CFR Part 20, 10 CFR Part 71, 29 CFR Part 1910, 49 CFR Part 172, 49 CFR Part 173
		DOE-HDBK-1140-2001, DOE-STD-1090-2001

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, PRD-013/T-027, and the requirements of the various mechanical handling systems. Applicable sections of these codes and standards will be determined during the design process and in the development of design products. ANSI N14.6-1993, *American National Standard for Radioactive Materials—Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More* [DIRS 102016], is an inactive code and standard that is still referenced within this section because certain sections contain information that may provide assistance in the design of special lifting devices.

[2] These NUREGs have been determined to be useful to the development of design products for the preliminary design. This regulatory guide has been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide.

[3] These Federal Regulations support compliance with requirements in PRD-015/P-020 and PRD-015/P-021 and PRD-015/P-015. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] The listed DOE directives support compliance with requirements of PRD-018/P-019. Applicable sections of these DOE directives will be determined during the design process and in the development of design products. The listed DOE handbook provides useful design guidance.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.7.1.2 General Mechanical Handling Design Criteria

Criteria

1. Mechanical handling systems shall have an operational life of 50 years. Mechanical handling equipment shall satisfy this criterion directly or be maintainable or easily replaced over the system lifetime.

2. The mechanical handling system shall be designed to meet the seismic criteria from Section 6.1.3.

3. Equipment designs with proven operational performance shall be used where possible. Similarly, existing technology, where available and suitable from other nuclear establishments, shall be used in the design of facilities and systems in preference to untried technology. The intent of these approaches is to minimize lifecycle costs. Where proven technology is not available, appropriate technical development and testing programs shall be undertaken to establish feasibility, reliability, and lifecycle cost.

4. Mechanical handling system components shall be designed to withstand and operate under the environmental conditions to which they will be exposed.

5. Mechanical handling equipment shall not damage the surface of the waste package.

6. Cranes, hoists, trolleys, and other load-handling devices shall be sized based on the weight of the heaviest load to be handled plus the weight of appurtenances such as skids, pallets, supports, yokes, and special lifting devices, as applicable.

7. Mechanical handling system components shall operate satisfactorily in the radiation environment to which they are exposed and shall withstand the cumulative effect of radiation exposure anticipated over their design life. Where the use of radiation-resistant components is not feasible, such components shall be easily replaceable.

8. Equipment, tools, and fixtures in areas with the potential for contamination shall have an appropriate surface finish and geometry to facilitate decontamination and prevent the accumulation and entrapment of contamination.

9. Mechanical handling systems that handle SNF shall promote criticality safety by meeting the applicable criteria of Section 4.9.2.2.

10. Mechanical handling systems shall include provisions for the inspection, testing, and maintenance of system equipment.

11. Mechanical handling systems shall meet the applicable fire protection criteria of Section 4.8.1 and incorporate the required design features identified in the applicable fire hazards analysis. Noncombustible and heat resistant materials shall be used to the extent practicable.

12. Mechanical handling systems shall provide overload limit sensing, collision avoidance, and alarming capabilities to automatically stop handling operations and warn operators of unsafe conditions only for specific SSCs as required by the PSA or other operational requirements.

13. Mechanical handling systems design shall include provisions for decontamination and decommissioning. See Section 4.2.3.3.8 for a listing of favorable design features.

14. For mechanical handling components that are ITS and are required to withstand design basis conditions for natural phenomena, applicable design criteria are discussed in Section 6.1. Design for tornados shall include Spectrum II tornado missiles.

15. Any overhead crane that is required to have a load drop probability less than 1×10^{-5} drops per transfer shall follow the guidelines of NUREG-0554 (NRC 1979 [DIRS 103347]) and be designed and constructed per ASME NOG-1 Type I [DIRS 158891]. Special lifting devices used with these cranes to handle loaded casks and waste packages shall be designed and constructed per ANSI N14.6-1993, *American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More* [DIRS 102016].

16. Overhead and gantry cranes and cask transporters shall not lift casks, canisters, or waste packages containing SNF or HLW higher than the design basis drop height above an unyielding surface. Where necessary to lift beyond the design basis drop height, impact absorbers or crush pads shall be used.

17 Recovery features shall be provided for cranes, trolleys, and similar equipment located in high or very high radiation areas to retrieve failed equipment to a shielded maintenance area. Alternatives, such as use of temporary shielding to permit in-place maintenance, may be employed in specific situations provided that ALARA criteria are met.

18. Mechanical handling systems shall incorporate design features such as quick connects/disconnects and long reach tools to reduce worker dose to meet ALARA principles as applicable.

Technical Rationale—The preceding design criteria represent good engineering practice and satisfy one or more of the following objectives:

1. Not used.
2. Achieve worker safety, including ALARA goals
3. Improve mechanical handling system reliability, maintainability, and availability.

4.7.1.3 Cask Receipt/Return System—Specific Design Criteria

Criteria—Means shall be provided to decontaminate external surfaces of the transportation package and ancillary equipment to meet the contamination limits of 49 CFR Part 172, Transportation: Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

[DIRS 173350], and 49 CFR Part 173, Transportation Shippers—General Requirements for Shipments and Packagings [DIRS 173279].

Technical Rationale—Decontamination capability required to satisfy federal law.

4.7.1.4 Non-Nuclear Handling System—Specific Criteria

No system-specific criteria.

4.7.1.5 Cask/MSC/WP Preparation System

Criteria—Means shall be provided to manually dry decontaminate external surfaces of the unloaded transportation package and ancillary equipment as required to meet the contamination limits specified in 49 CFR Part 173 [DIRS 173279].

Technical Rationale—Decontamination capability required to satisfy federal law.

4.7.1.6 SNF/HLW Transfer System—Specific Criteria

Criteria

1. The system design shall incorporate features for safe shutoff of the power supply (i.e., this may include remote and manual disconnects) to the transfer system equipment in an off-normal situation.

2. The system design shall maintain the capability to continue transfer operations with a single failure in the transfer cell or provide failure recovery capabilities until corrective maintenance can be implemented.

3. The operating areas shall provide shield windows and/or remote viewing systems (CCTV) to assist operators in performing required operations and recovery from off-normal events.

4. Remote manipulators shall provide capability to recover from off-normal scenarios such as release of a stuck grapple or yoke.

5. Grapples and tools shall be designed for ease of decontamination, nondestructive testing, maintenance, handling, and storage.

6. Fixtures, temporary storage locations, fuel unit container, and similar devices shall be designed with appropriate lead-ins and chamfers to facilitate and guide insertion and removal for remote assembly and disassembly operations.

Technical Rationale—The preceding design criteria represent good engineering practice and satisfy one or more of the following objectives:

1. Not used.
2. Achieve worker safety, including ALARA goals
3. Improve mechanical handling system reliability, maintainability, and availability.

4.7.1.7 Remediation System-Specific Criteria

Criteria

1. The operating areas shall provide shield windows and/or remote viewing systems (CCTV) to assist operators in performing required operations and recovery from off-normal events.

2. Capability for emergency shutdown of the lifting and handling equipment power supply (i.e., manual disconnect) shall be incorporated into the equipment design.

3. If provision for remote maintenance is not provided, handling equipment for SNF assemblies and transportation package closure lid(s) shall have sufficient redundancy so that no single failure in the handling system will preclude returning unshielded SNF assemblies to shielded storage location.

4. Grapples and lifting attachments and handling equipment for SNF assemblies and transportation package closure lid(s) shall be designed for remote operation, and active lifting components shall be designed to retain their load in the event of loss of actuating power.

5. Grapples and tools shall be designed to facilitate decontamination and maintenance and provide staging/storage area.

6. The remediation system shall include equipment and facilities (pool) to support recovery from off-normal events involving radiation.

Technical Rationale—The preceding design criteria represent good engineering practice and satisfy one or more of the following objectives:

1. Not used.
2. Achieve worker safety, including ALARA goals
3. Improve mechanical handling system reliability, maintainability, and availability.

4.7.1.8 Spent Nuclear Fuel Aging System-Specific Criteria

Criteria

1. The aging system transporter must be constructed to allow the operator clear visibility while operating in the travel direction and not expose the operator to elevated radiation levels, noise, dust, or other constituents above the threshold limits.

2. The aging system transporter must, when operating in reverse, have a movement alarm system.

3. The transporter tracks/wheels will not damage concrete floors.

Technical Rationale—The preceding design criteria represent good engineering practice and satisfy one or more of the following objectives:

1. Not used.
2. Achieve worker safety, including ALARA goals
3. Improve mechanical handling system reliability, maintainability, and availability.

4.7.1.9 Emplacement and Retrieval System-Specific Criteria

Criteria

1. Waste package retrieval equipment shall have a maintainable and/or replacement life of 100 years.

2. Capability for the emplacement equipment to acquire the waste package identification number and record the location in the drift shall be maintained.

Technical Rationale—Waste package retrieval equipment life is based on the 10 CFR 63.111e [DIRS 173273] requirement that the repository be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule, starting at any time up to 50 years after waste emplacement operations are initiated, and assumes a 50-year maximum retrieval period. The ability to acquire and record waste package identification is a basic functional requirement and facilitates potential retrieval.

4.8 MECHANICAL DESIGN CRITERIA

4.8.1 Fire Protection Design Criteria

4.8.1.1 Fire Protection Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Mechanical	Fire Protection[b]	ASTM D 5144-2000, ICC 2000 [DIRS 159179], ICC 2002, NFPA 1-2003, NFPA 10-2002, NFPA 101®-2003, NFPA 11-2005, NFPA 1144-2002, NFPA 13-2002, NFPA 14-2003, NFPA 15-2001, NFPA 16-2003, NFPA 17-2002, NFPA 1963-2003, NFPA 20-2003, NFPA 2001-2000, NFPA 214-2005, NFPA 22-2003, NFPA 221-2000, NFPA 24-2002, NFPA 25-2002, NFPA 30-2003, NFPA 502-2004, NFPA 51B-2003, NFPA 68-2002, NFPA 69-2002, NFPA 70-2004, NFPA 72-2002, NFPA 75-2003, NFPA 750-2003, NFPA 780-2004, NFPA 80-1999, NFPA 801-2003, NFPA 80A-2001, NFPA 90A-2002, UL 2003 [DIRS 167310], UL 2003 [DIRS 167311], UL 2003 [DIRS 167312], UL 2003 [DIRS 164301], UL 2003 [DIRS 166979]
		NUREG-0800 (NRC 1989 [DIRS 165112]), Regulatory Guide 1.189, Regulatory Guide 8.8
		10 CFR Part 20, 10 CFR Part 73, 29 CFR Part 1910
		DOE O 420.1A, DOE G 440.1-5, DOE-STD-1066-99

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the fire protection system. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This NUREG has been determined to be useful to the development of design products for the preliminary design. These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-005, PRD-015/P-020, and PRD-015/P-021. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] Addressing these DOE directives supports compliance with requirements of PRD-018/P-019. Applicable sections of these DOE directives will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.8.1.2 Facilities Hazard Classification

Criteria—Facilities at the repository shall handle large quantities of radioactive and hazardous materials. Consequently, it is necessary to ensure that facilities are designed to control, suppress, and contain the effects of fire events that are postulated to occur during the life of the facility.

To ensure that adequate levels of fire protection are provided, a graded approach is used in the design of facilities and areas.

4.8.1.3 Applicable Design Codes and Standards to Fire Protection Design

Table 4.8.1-1. Applicable Design Codes and Standards to Fire Protection Design

Title	Applicability	Surface Facilities		Subsurface Areas	
		Nuclear Buildings	Non-Nuclear Buildings	Development Area	Emplacement Area
NFPA 10-2002, Standard for Portable Fire Extinguishers [DIRS 160950]	Sizing and spacing of portable fire extinguishers for all accessible areas	X	X	X	X
NFPA 11-2005, Standard for Low-, Medium-, and High-Expansion Foam [DIRS 173508]	Design of foam based fire suppression systems	X	X	X	
NFPA 13-2002, Standard for the Installation of Sprinkler Systems [DIRS 160921]	Selection and design of automatic sprinkler systems	X	X		
NFPA 14-2003, Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems [DIRS 165074]	Layout and design of all standpipe and hose station outlets for backup suppression and fire brigade use	X		X	
NFPA 15-2001, Standard for Water Spray Fixed Systems for Fire Protection [DIRS 159163]	Layout and design of fixed water spray systems in buildings and external areas	X	X		
NFPA 16-2003, Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems [DIRS 173509]	Layout and design of foam water suppression systems	X	X		
NFPA 17-2002, Standard for Dry Chemical Extinguishing Systems [DIRS 160951]	Design of fire suppression systems for mobile equipment	X	X	X	X
NFPA 20-2003, Standard for the Installation of Stationary Pumps for Fire Protection [DIRS 165722]	Design and specification of fire water pumping system	X	X	X	
NFPA 22-2003, Standard for Water Tanks for Private Fire Protection [DIRS 165075]	Design and layout of fire water storage	X	X	X	
NFPA 24-2002, Standard for the Installation of Private Fire Service Mains and Their Appurtenances [DIRS 160922]	Design, arrangement, and piping material selection for fire water distribution	X	X	X	
NFPA 25-2002, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems [DIRS 160952]	Design considerations for the inspection, testing, and maintenance of water based extinguishing systems	X	X	X	

Table 4.8.1-1. Applicable Design Codes and Standards to Fire Protection Design (Continued)

Title	Applicability	Surface Facilities		Subsurface Areas	
		Nuclear Buildings	Non-Nuclear Buildings	Development Area	Emplacement Area
NFPA 750-2003, Standard on Water Mist Fire Protection Systems [DIRS 173516]	Design of limited water usage fire suppression systems	X	X	X	
NFPA 2001-2000, Standard on Clean Agent Fire Extinguishing Systems [DIRS 154764]	Design of non-aqueous suppression systems	X	X	X	
NFPA 101®-2003, Life Safety Code® [DIRS 165076]	Design of facility egress Systems	X	X		
NFPA 214-2005, Standard on Water-Cooling Towers [DIRS 173512]	Protection of Cooling Towers		X		
NFPA 221-2000, Standard for Fire Walls and Fire Barrier Walls [DIRS 160949]	Design of fire barriers and fire walls	X	X	X	X
ICC 2000, International Building Code [DIRS 159179]	Facility design, layout, separation, and protection	X	X		
Regulatory Guide 1.189 [DIRS 155040]	Design and requirements for selection of fire protection systems	X	X		X

4.8.1.4 General Criteria

4.8.1.4.1

Criteria—The system shall provide automatic fire suppression in facilities that have a ground floor area in excess of 5,000 sq ft or where the maximum fire loss exceeds $1 million.

Technical Rationale—The DOE imposes DOE O 420.1A, *Facility Safety* [DIRS 159450], on the repository. DOE G 440.1-5, *Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety Program* [DIRS 144423], Section IV, Paragraph 9.7, requires automatic fire suppression in facilities where the maximum possible fire loss exceeds $1 million or the ground floor area is in excess of 5, 000 sq ft.

4.8.1.4.2

Criteria—The system shall provide redundant fire protection in areas where the maximum possible fire loss exceeds $50 million.

Technical Rationale—DOE G 440.1-5 [DIRS 144423], Section IV, Paragraph 9.7, requires redundant fire protection in areas where the maximum possible fire loss exceeds $50 million. Redundant fire protection can include items such as a fire barrier system, smoke detection in

Table 4.8.1-1. Applicable Design Codes and Standards to Fire Protection Design (Continued)

conjunction with a fully capable fire department, and other options. Fire protection in this criterion means fire detection, suppression, and alarm features, as needed, to protect against the fire and explosion hazards.

4.8.1.5 Site Criteria

4.8.1.5.1

Criteria—The minimum access width, building to building spacing, for fire fighting apparatus shall be not less than 26 ft where fire hydrants are provided and shall not be less than 20 ft in width where there are no hydrants. Access pathways shall not exceed 150 ft in length unless a suitable turnaround is provided.

Technical Rationale—This criterion provides for acceptable width for the access and operation of fire fighting apparatus per the International Fire Code, Sections 503.2.5, D103.1, and D103.4 (ICC 2002 [DIRS 159660]).

4.8.1.5.2

Criteria—Roads that are used by fire fighting apparatus shall not exceed 10 percent in grade.

Technical Rationale—This criterion provides for acceptable slope for the response of fire fighting apparatus per the International Fire Code (ICC 2002 [DIRS 159660], Section D.103.2).

4.8.1.5.3

Criteria—Exposures to buildings and significant equipment from the natural terrain shall be assessed and mitigated per NFPA 1144-2002, *Standard for Protection of Life and Property from Wildfire* [DIRS 160936].

Technical Rationale—This criterion assists in the identification, assessment of risk, and specification of mitigating features in order to protect buildings and equipment from external fire threats due to the isolated location in an area that could be threatened by wild land fires.

4.8.1.5.4

Criteria—Exterior exposures to buildings or equipment created by other buildings or equipment shall be evaluated and mitigated in accordance with NFPA 80A-2001, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures* [DIRS 160934].

Technical Rationale—This criterion assists in the identification, assessment of risk, and specification of mitigating features in order to protect buildings and equipment from fires in adjacent buildings or equipment.

4.8.1.5.5

Criteria—The location, spacing, and protection criteria for flammable and combustible liquid tanks shall be identified, evaluated, and mitigated per NFPA 30-2003, *Flammable and Combustible Liquids Code* [DIRS 173510].

Technical Rationale—This criterion assists in the identification, assessment of risk, and specification of mitigating features to protect flammable and combustible tanks from adversely affecting other buildings and equipment from fire.

4.8.1.6 Nuclear Surface Facilities

4.8.1.6.1

Criteria—Noncombustible and heat resistant building materials shall be used wherever practical.

Technical Rationale—This criterion is necessary to limit the quantities of materials available to support combustion in a hazard area. Fire propagation is limited by restricting building materials to the use of noncombustible and heat resistant materials that will not support combustion. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B., GDC 3, which specifies the use of noncombustible and heat resistant materials.

4.8.1.6.2

Criteria—Required fire detection and suppression systems of appropriate capacity and capability shall be designed to minimize the adverse effects of fires on SSCs ITS.

Technical Rationale—This criterion is necessary to specify that the system design will be sufficiently comprehensive and adequate to limit damage from a fire and protect against an inadvertent release to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B., GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard.

4.8.1.6.3

Criteria—Fire fighting systems shall be designed to ensure that their failure, rupture, or inadvertent operation does not significantly impair the capability of SSCs ITS to perform their intended function.

Technical Rationale—This criterion is necessary to specify that the system design will be sufficiently comprehensive and adequate to limit damage from a fire and protect against inadvertent release to affected SSCs in the hazard area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B., GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard.

4.8.1.6.4

Criteria—Backup fire suppression in the form of a NFPA 14-2003, *Standard for the Installation of Standpipe and Hose Systems* [DIRS 165074], Class III, installation shall be provided in all nuclear facilities. The system shall be able to reach any location that contains or could present an exposure fire hazard to SSCs ITS with at least one effective hose stream. Additional standpipe and hose installations shall be provided in an area if the fire hazard could block access to a single hose station serving that area. All hose nozzles shall have shutoff capability.

Technical Rationale—This criterion is necessary to specify a minimum threshold level for backup fire system protection that is acceptable in order to limit damage from a fire. Specification of backup suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.4, which specifies this criterion for manual suppression systems.

4.8.1.6.5

Criteria—The design interface, control, and usage of the building ventilation and exhaust systems shall be accomplished in a manner consistent with NFPA 801-2003 [DIRS 165077]. Fire and smoke damper specifications shall include parameters to ensure satisfactory closure performance that addresses the total worst-case differential pressures at the damper under airflow conditions.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.2.1.3, which specifies the criteria for ventilation system fire dampers.

4.8.1.7 Non-Nuclear Surface Facilities

Criteria—Automatic suppression shall be installed as determined by the fire hazards analysis, as necessary, to protect against fires and to limit the maximum possible fire loss. The basis for the choice of particular system style for protection shall be described in the fire hazards analysis. Light hazard occupancy sprinkler system design densities shall not be used.

Technical Rationale—This criterion is necessary to specify a minimum level of protection that is acceptable to the DOE before an automatic fire protection system is required to limit damage from a fire. Specification of an appropriate and comprehensive fire protection system of sufficient capacity and capability will increase the likelihood that fires are satisfactorily controlled and extinguished. This criterion implements DOE O 420.1A [DIRS 159450] and DOE-STD-1066-99 [DIRS 154954], Sections 5.3.1, 5.3.2, and 7.1, which specify the criterion for fire protection when the maximum possible fire loss exceeds $1 million.

4.8.1.8 Subsurface Development Area/Construction Phase

Criteria—The zoning of fire detection, alarm, and suppression systems shall be compatible with the layout of the subsurface ventilation system. The zoning of the fire protection systems shall permit the operational control of the subsurface ventilation system on a selective fan basis.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Fire hazards with adequate fire protection system performance and capability, together with specific egress features, will aid in providing life safety for occupants to meet DOE criteria for occupant protection. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2, which specifies the criteria for minimum level of life safety performance to demonstrate that occupants are adequately and appropriately protected from fire hazards.

4.8.1.9 Subsurface Emplacement Area/Repository Phase

Criteria—The subsurface development area/construction phase shall be separated from the subsurface emplacement area/repository phase by a fire rated barrier(s) with a performance rating as determined by the fire hazards analysis. The fire barrier may be coincident with a ventilation barrier but shall meet all the requirements of NFPA 221-2000, *Standard for Fire Walls and Fire Barrier Walls* [DIRS 160949].

Technical Rationale—This criterion is necessary to specify a level of fire barrier performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and associated fire hazards. Specification of fire barrier parameters increases the likelihood that a fire is contained within the subsurface development area and not extended to the subsurface emplacement area. This criterion is based on Regulatory 1.189 [DIRS 155040], Section 4.2.1.4, which specifies the criteria for fire area compartmentation.

4.8.1.10 Protection of Mobile Equipment

4.8.1.10.1

Criteria—Automatic fire detection and suppression of appropriate capacity and capability shall be installed as determined by the fire hazards analysis and as necessary to protect SSCs. The fire hazards analysis shall consider the worst-case location and exposure impact to SSCs in determining the protection required. The agent used for automatic suppression shall be based on the fire hazards analysis and any potential ITS concerns.

Technical Rationale—This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. Specification of mobile equipment automatic suppression limits potential fire damage to SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.3, which specifies the criteria for the protection of SSCs ITS.

4.8.1.10.2

Criteria—The required mobile equipment fire detection and suppression system shall be designed to transmit signal(s) to the site fire alarm system to annunciate the equipment location and status whether within or exterior to any building, structure, or exterior area where the equipment is expected to operate. The manner in which this signal(s) is transmitted and received shall minimize against adverse effects to SSCs ITS.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to promptly control and extinguish a fire, and also protect against the inadvertent release to affected SSCs caused by undesirable plant systems interaction. Fire protection systems of sufficient capacity and capability, with normal and abnormal system status indications, will enable fires to be controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B., GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability to be provided for the protected hazard.

4.8.1.11 Fire Protection System Redundancy

Criteria—Redundant fire protection systems shall be provided in areas containing SSCs ITS where the resulting protection would not otherwise ensure that the fire would be successfully controlled until such time that the emergency fire fighting forces are expected to arrive to complete fire extinguishment. Redundant fire protection could consist of duplicate localized hazard protection or the installation of a local hazard fire suppression system together with an appropriately designed area fire suppression system that would protect the entire fire area or hazard space.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage, from a fire and from inadvertent release, to affected SSCs in a hazard area. Fire protection systems of sufficient capacity and capability, with normal and abnormal system status indications, will enable fires to be controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B., GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability, and DOE G 440.1-5 [DIRS 144423], Section IV, 9.6, which specifies additional protection when the manual fire fighting force is delayed in effecting extinguishment.

4.8.1.12 Life Safety Provisions/Surface Facilities

4.8.1.12.1

Criteria—Acceptable life safety provisions shall be provided for all facilities. Compliance with NFPA 101®-2003 [DIRS 165076] is considered to satisfy DOE O 420.1A [DIRS 159450].

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Fire hazards with adequate fire protection system performance of sufficient capacity and capability, together with personnel specific egress features, will provide acceptable life safety for facility occupants to meet DOE criteria for occupant protection. This criterion is based on DOE O 420.1A

[DIRS 159450], Section 4.2, and DOE-STD-1066-99 [DIRS 154954], Section 10.1, which specify the criteria for minimum level of life safety performance to demonstrate that facility occupants are adequately and appropriately protected from fire hazards.

4.8.1.12.2

Criteria—Where hazardous processes are of a sufficient character as to introduce an explosion potential in a building compartment, personnel life safety protection features per NFPA 101®-2003 [DIRS 165076], shall be provided that may be additional to that specified below in Section 4.8.1.18.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide adequate levels of life safety in areas where an explosion potential exists. This criterion is based on NFPA 101®-2003 [DIRS 165076], Sections 8.7.1.1 and 8.7.2, which specify the criteria for a minimum level of life safety performance to demonstrate that facility occupants are adequately and appropriately protected.

4.8.1.12.3

Criteria—Exposed interior wall and ceiling finish materials and any factory installed facing materials shall have a UL-listed or Factory Mutual-approved flame spread rating of 25 or less and smoke developed rating of 50 or less. Interior finishes in areas processing or storing radioactive materials shall have limited combustible rating.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive to provide an adequate level of life safety. This criterion is based on DOE-STD-1066-99 [DIRS 154954], Section 9.3.1, ICC 2000 [DIRS 159179], Section 803, NFPA 101®-2003 [DIRS 165076], Section 10.2.3, and NFPA 801-2003 [DIRS 165077], Section 5.8, for radioactive materials. These specify the criteria for the minimum levels of passive fire protection performance to demonstrate that facility occupants and property are adequately protected from fire hazards.

4.8.1.13 Life Safety Provisions/Subsurface Areas

4.8.1.13.1

Criteria—A fire command center shall be provided on the surface for the use of fire fighting forces during an emergency in the subsurface. This may be collocated with other surface or subsurface control equipment but shall meet the space and survivability criteria of NFPA 72-2002, *National Fire Alarm Code* [DIRS 160954], Section 6.9.6. The fire command center shall have displays for the status of all detection, alarm, and communication systems in the subsurface. This shall be the principal location for handling a subsurface emergency and from where subsurface systems credited for fire and worker protection can be manually controlled. Status, display, and command override functions shall be provided for all credited subsurface ventilation system dampers and fan controls. All required status, display, communications and functional controls shall be monitored for integrity.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Fire hazards with adequate fire protection system performance of sufficient capacity and capability, together with personnel specific egress features, will provide acceptable life safety for facility occupants to meet DOE criteria for occupant protection. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2, which specifies the criteria for minimum level of life safety performance to demonstrate that a facility occupants are adequately and appropriately protected from fire hazards.

4.8.1.13.2

Criteria—Provisions shall be provided to preclude and minimize the entrainment of smoke from the surface to the subsurface due to an exposure surface fire near subsurface air intake structures or vent lines. These provisions shall be adaptable to the needs of the subsurface as emplacement and development activities continue to evolve.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Protection from external fire hazards, together with personnel egress and refuge features, will provide acceptable capacity life safety for occupants to meet DOE criteria for occupant protection. This criterion is compatible with DOE O 420.1A [DIRS 159450], Section 4.2, which specifies the criteria for minimum level of life safety performance to demonstrate that facility occupants are adequately protected from fire hazards internal and external to the facility.

4.8.1.14 Fire Water System

4.8.1.14.1 Fire Water Storage

4.8.1.14.1.1

Criteria—The fire water supply for nuclear facilities shall be calculated on the basis of the largest expected flow rate for a period of two hours, but not less than 300,000 gal. This flow rate shall be conservatively based on 500 gpm for manual hose streams, plus the largest design demand of any sprinkler or deluge system as determined by hydraulic calculation. Fire water service to non-nuclear buildings, except the subsurface zone, may be serviced by the fire water system as permitted in the fire water system criteria.

Technical Rationale—This criterion is necessary in order to specify a system design that will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, with allowance for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.2.1.b, which specifies that the use of fire protection systems of appropriate capacity and capability be provided for the protected hazard.

4.8.1.14.1.2

Criteria—At least two 100-percent system capacity dedicated fire water supply tanks shall be installed. The site water supply system shall be capable of totally refilling the tank in eight continuous hours or less.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.2.1.a and c, which specify the use of fire protection systems of appropriate capacity and capability for the protected hazard.

4.8.1.14.2 Fire water Pumping

Criteria—If fire pumps are provided, a sufficient number of pumps shall be provided to ensure that 100 percent capacity will be available assuming failure of the largest pump or loss of offsite power (e.g., three 50-percent pumps or two 100-percent pumps). This may be accomplished by providing a combination of electric motor-driven fire pumps and diesel-driven fire pumps.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.2.2, which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard.

4.8.1.14.3

Criteria—Individual fire pump connections to the yard fire main loop shall be separated with appropriate sectionalizing valves between connections. Diesel-driven fire pumps, together with the pump driver and controls, shall be located in a room separated from the remaining fire pumps by a firewall with a minimum fire rating of three hours. Fire pump status signals shall be provided to annunciate pump running, driver availability, failure to start, and low fire-main pressure to the main control room.

Technical Rationale—This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.2.2.b and c, which specify the use of fire protection systems of appropriate capacity and capability for the protected hazard.

4.8.1.14.4 Fire water Distribution Piping

4.8.1.14.4.1

Criteria—The fire water distribution piping shall be of a looped type grid that provides two-way water flow. Fire water piping, except the subsurface zone, shall be separate from all other water piping systems. Sectional valves shall be arranged to provide alternate water flow paths to any point in the system. The fire water loop shall be sized as required to furnish anticipated water criteria; the type of pipe and any required water treatment should consider the possible effects of tuberculation. Sectional control valves shall be provided to limit the number of hydrants and individual sprinkler systems made inoperative during a single line break or impairment to a maximum of five.

Technical Rationale—This criterion is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage from a fire. Specification of an upper limit in the number of suppression systems and hydrants out of service for an impairment increase the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.2.3.a and GDC 3; DOE O 420.1A [DIRS 159450]; and DOE-STD-1066-99 [DIRS 154954], Section 6.2.2, which specify the criterion for the arrangement of the fire water distribution system.

4.8.1.14.4.2

Criteria—Control valves shall also be provided to isolate portions of the fire water system serving SSCs, which are or contain SSCs ITS from portions of the fire water system serving SSCs that are not or do not contain SSCs ITS, without simultaneously shutting off the fire water supply to areas containing SSCs ITS. The fire water distribution piping shall be capable of delivering this design demand over the longest piping route to the protected hazard. The distribution piping shall be capable of meeting the calculated design demand at a residual pressure not less than 20 psig at ground elevation.

Technical Rationale—This criterion is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage to SSCs ITS in the event of a fire. Specification of isolation valves to prevent the simultaneous unavailability of primary and backup suppression systems from any impairment increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.2.3.g and h and GDC 5, and DOE-STD-1066-99 [DIRS 154954], Section 6.1.1, which specify the criterion for the arrangement of the fire water distribution system in regard to impairment of the primary and backup fire suppression system.

4.8.1.14.4.3

Criteria—Control and sectionalizing valves in fire mains and water-based fire suppression systems shall be electrically supervised. Electrical supervision signals shall transmit to the location of the fire alarm monitoring console. Control and sectional valves shall be visually indicating type valves.

Technical Rationale—This criterion is necessary to specify a level of fire system status indication that is acceptable in order to limit damage from a fire. Specification of a valve type and its position supervision when out of service for impairment increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.2.3.d, which specifies the criteria for the valve supervision of the fire water distribution system.

4.8.1.14.4.4

Criteria—Sprinkler systems and backup standpipe and hose stations shall be provided with connections to the fire water distribution system so that a single active failure or line break will not simultaneously impair the primary and backup fire suppression systems. Alternatively, fire water headers fed from two ends are permitted inside buildings to supply sprinkler and standpipe systems. Such headers shall be considered an extension of the fire water distribution system. Each sprinkler and standpipe system shall be separately equipped with a means to detect water flow and transmit a water flow condition to a remote location.

Technical Rationale—This criterion is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage from a fire. Specification of configuration limits the simultaneous impairment of primary and backup suppression systems out of service for impairment increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.2.3.i, which specifies the criterion for the arrangement of the fire water distribution system.

4.8.1.14.5 Fire Hydrants

4.8.1.14.5.1

Criteria—Fire hydrants shall be capable of providing the water flow rates established in the International Fire Code (ICC 2002 [DIRS 159660]) based on the most severe facility fire risk on site. This rate shall be reduced by a maximum of 50 percent, in accordance with DOE-STD-1066-99 [DIRS 154954], for automatic sprinkler protected facilities. Fire hydrants shall each be capable of flowing a minimum of 1,500 gpm at 20-psig residual pressure.

Technical Rationale—This criterion is necessary to specify a defense-in-depth design that will be sufficiently comprehensive and adequate to limit damage from a fire should one of the systems not be able to perform as intended to control a fire in the hazard area. The establishment of fire hydrant minimum waterflow rates will ensure that a sufficient capacity is available for manual fire fighting, which will increase the likelihood that fires are promptly controlled and extinguished. This fire hydrant criteria is based on the International Fire Code (ICC 2002 [DIRS 159660], Sections B102.1 and B105.2 and Table B105.1) and DOE-STD-1066-99 [DIRS 154954], Section 6.1.2.

4.8.1.14.5.2

Criteria—Fire hydrants shall be located so that a sufficient and effective hose stream can be provided to any onsite location where fixed or transient combustibles could jeopardize ITS and non-SC facility SSCs. Hydrants shall be installed approximately every 250 ft on the fire water distribution system. Valves shall be installed to permit isolation of fire hydrants from other portions of the fire water distribution system for maintenance or repair without interrupting the water supply to other portions of the distribution system. Hose threads compatible with those used by local fire departments shall be provided on all hydrants, hose couplings, and standpipe risers consistent with NFPA 1963-2003, *Standard for Fire Hose Connections* [DIRS 166981].

Technical Rationale—This criterion is necessary to specify a maximum level of fire system inoperability that is acceptable to the NRC in order to limit damage from a fire. Specification of a system configuration, which limits the simultaneous impairment of primary and backup suppression systems out of service for impairment, increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.2.3.h and 3.4.2, which specify the criteria for the arrangement of the fire water distribution system.

4.8.1.14.6 Fire Water System-Subsurface Zone

The design criteria for the separately piped and zoned subsurface fire water system will be determined at a later date.

4.8.1.15 Fire Detection System

4.8.1.15.1

Criteria—Fire detection systems shall be provided in all areas that contain or present a fire exposure to SSCs ITS. Fire detection systems comply with the criteria for Class A systems (NFPA 72-2002 [DIRS 160954]) and Class I circuits (NFPA 70-2004 [DIRS 172711]).

Technical Rationale—This criterion is necessary to specify a minimum threshold level for automatic fire detection system performance that is acceptable to limit damage from a fire. Specification of automatic detection performance limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.1, 3.1.1.b, d, e, and i, which specify the criteria for the protection of SSCs ITS.

4.8.1.15.2

Criteria—Fire detection systems shall be capable of operating with or without offsite power.

Technical Rationale—This criterion is necessary to specify a level of fire detection system performance that is acceptable to limit damage from a fire. Specification of the capability for the fire detection system to detect fires when offsite power is available or unavailable increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189, [DIRS 155040] Section 3.1, which specifies the criteria for fire detection performance during normal and off-normal conditions.

4.8.1.15.3

Criteria—Fire detection shall be provided for all other buildings and areas where fire damage is postulated to occur per a fire hazards analysis and no other fire protection system is provided.

Technical Rationale—This criterion is necessary to specify performance for fire detection systems in buildings and areas, which would otherwise not be provided with fire suppression. Specification of a fire detection system will increase the likelihood that fires are promptly controlled and extinguished. This criterion implements DOE O 420.1A [DIRS 159450], Section 4.2.2.6; and DOE G 440.1-5 [DIRS 144423], Section III, 2.0 and 6.6, and Section IV, 9.6, which specify the criteria for fire protection when other fire suppression are not otherwise installed.

4.8.1.16 Fire Suppression System

4.8.1.16.1

Criteria—Automatic suppression shall be installed as determined by the fire hazards analysis and, as necessary, to protect SSCs ITS. The type of automatic suppression chosen for protection shall be based on the fire hazards analysis and any potential ITS concerns.

Technical Rationale—This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.3, which specifies the criteria for the protection of SSCs ITS.

4.8.1.16.2

Criteria—SSCs ITS that do not otherwise require protection by water-based suppression systems, but are subject to unacceptable damage if wetted by water suppression discharge, shall be appropriately protected by water shields or baffles.

Technical Rationale—This criterion is necessary to specify protection feature levels for automatic fire system protection to limit damage from unintended system discharge effects to SSCs. Specification of water shields or baffles where automatic suppression systems are located limits potential unintended damage to SSCs ITS. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.3.1, which specifies the criterion for the protection of SSCs ITS.

4.8.1.16.3

Criteria—Water mist suppression systems shall be considered for use in specialized situations where the application of water needs to be restricted. The basis for selection of a water mist system as for hazard protection shall be documented in the fire hazards analysis.

Technical Rationale—This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.3.1 and 3.3.1.2, which specify the criteria for the protection of SSCs ITS.

4.8.1.16.4

Criteria—Hydraulically designed automatic and manual suppression systems shall be designed for a supply pressure of at least 10 percent but not less than 10 psig below the supply curve.

Technical Rationale—This criterion is necessary to specify a margin of safety in system design that will be sufficiently comprehensive and adequate to limit damage from a fire should one of the systems not be able to perform as intended to control a fire in the hazard area. The specification of a safety margin in the design of fire suppression systems ensures that systems of sufficient capacity and capability will be available, which will increase the likelihood that fires are promptly controlled and extinguished. This criterion implements DOE O 420.1A [DIRS 159450] and DOE-STD-1066-99 [DIRS 154954], Section 7.2, which specify the criterion for hydraulic design of suppression systems in DOE facilities.

4.8.1.16.5

Criteria—Floor drains, curbs, ramps or sills shall be sized to accommodate anticipated fire fighting water without the flooding SSCs ITS in all areas where automatic or manual water fire suppression systems are installed. Facility design shall also ensure that fire water discharge in one area does not affect SSCs ITS in adjacent areas. The size and method of collection for fire suppression water shall be determined in a manner consistent with NFPA 801-2003 [DIRS 165077].

Technical Rationale—This criterion is necessary to specify protection from the accumulation of fire water system discharge at an acceptable level to limit damage from fire water flooding. Specification of protection from fire water flooding limits potential fire damage to SSCs ITS and increases the likelihood that necessary or inadvertent fire system discharges do not result in degraded SSC performance. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2.3; Regulatory Guide 1.189 [DIRS 155040], Section 4.1.5; and NFPA 801-2003 [DIRS 165077], Section 3-10, which specify the criterion for the protection of SSCs ITS for inadvertent effects of fire water system discharge.

4.8.1.16.6

Criteria—Fire protection for high-efficiency particulate air (HEPA) filter combustion shall protect against the potential of spread fire to other facility areas. A fire hazards analysis shall determine the need for and the type of fire detection and suppression for the HEPA filters and their exposure to SSCs ITS.

Technical Rationale—This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.4, and DOE-STD-1066-99 [DIRS 154954], Section 14, which specify the criteria for the protection of SSCs ITS.

4.8.1.16.7

Criteria—Foam water systems fire suppression protection shall be considered where significant flammable and combustible liquid fire hazards are present. This shall be documented in the fire hazards analysis.

Technical Rationale—Specification of an appropriate and comprehensive fire protection system of sufficient capacity and capability will increase the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses are incurred. This criterion implements DOE O 420.1A [DIRS 159450] and DOE-STD-1066-99 [DIRS 154954], Sections 5.3.1 and 5.3.2, which specify the criteria for fire protection when the maximum possible fire loss exceeds $1 million.

4.8.1.16.8

Criteria—When the use of water sprinklers is precluded because of nuclear criticality concerns, non-aqueous fire extinguishing subsystems shall be used. Confirmation that the extinguishing subsystems selected do not pose a criticality concern shall be demonstrated with an appropriate nuclear criticality analysis.

Technical Rationale—This criterion is necessary to specify fire protection means when a water-based fire suppression system discharge could produce an undesired criticality event. Specification of alternative fire protection agents will limit potential fire damage to SSCs ITS, increasing the likelihood that fire may still be controlled and extinguished, as well as the prevention of a criticality event during discharge of the fire system agent. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.3.1 and 3.3.2, which specify the criteria for protection using automatic suppression systems.

4.8.1.16.9

Criteria—Alternative halon or clean agent fire-extinguishing systems shall only use listed or approved agents. Provisions for locally disarming automatic systems shall be key-locked. The basis for selection of given clean agent systems for hazard protection shall be documented in the fire hazards analysis.

Technical Rationale—This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 1.2, 3.3.2, and 3.3.2.3, which specify the criterion for the protection of SSCs ITS.

4.8.1.16.10

Criteria—The introduction of the fire-extinguishing agent into a compartment shall not result in over-pressurization and failure of the ventilation confinement system barrier.

Technical Rationale—This criterion is necessary to specify limits to fire protection agent discharge that could otherwise produce a loss of confinement. Specification of a limit on the pressure effects from alternative fire protection agent discharge will allow a fire to be controlled and extinguished, as well as prevent potential loss of ventilation system confinement. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.3.2, which specifies the criterion for protection using gaseous fire suppression systems.

4.8.1.17 Fire Alarm System

Criteria—The site fire alarm system shall be designed to minimize the adverse effects of fires on SSCs ITS. The site fire alarm system shall be a proprietary type system and installed in all site buildings and areas to connect all active fire protection systems with the main fire alarm monitoring console and other required system interfaces. The fire alarm system shall be capable of operating with or without offsite power.

Technical Rationale—This criterion is necessary to specify a level of fire alarm system performance that is acceptable in order to limit damage from a fire. Specification of the capability for the fire alarm system to transmit fire related signals when offsite power is available and unavailable increases the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses are incurred. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 3.1, 3.1.1.a, and f, which specify the criteria for fire alarm performance during normal and off-normal conditions.

Criteria—Local fire alarm occupant notification shall be provided for the protected zone originating the alarm. A fire zone alarm panel or graphic zone alarm panel shall be provided at the main entrance to major facilities. A manual fire notification method, such as a manual fire alarm station, shall be provided at all normally occupied facilities.

Technical Rationale—This criterion is necessary to specify a level of fire alarm system performance that is acceptable to the NRC and the DOE in order to limit damage from a fire. Specification of the capability for the fire alarm system features at the local protected hazard area increases the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses incur and provides for acceptable levels of life safety. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3.1.1.d; DOE O 420.1A [DIRS 159450]; and DOE-STD-1066-99 [DIRS 154954], Sections 8.1 and 8.2, which specify the criteria for fire alarm performance at the local protected hazard area.

Criteria—Signaling line circuits serving the subsurface shall be separate from those serving surface facilities, except ventilation shaft fan houses.

Technical Rationale—This criterion is necessary to specify a level of fire alarm system performance that is acceptable in order to limit damage from a fire. Specification of the separate signaling line circuits for the surface and subsurface reduces the probability that faults on the surface will not affect subsurface fire alarm capability and vice versa. This increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 3, which specifies the criteria for fire alarm performance.

4.8.1.18 Explosion Protection System

4.8.1.18.1

Criteria—In situ explosion hazards shall be identified and suitable protection provided. Transient explosion hazards that cannot be eliminated shall be controlled and suitable protection provided. Explosion hazards and their specific means of protection shall be discussed in the fire hazards analysis. NFPA 68-2002, *Guide for Venting of Deflagrations* [DIRS 159165], and NFPA 69-2002, *Standard on Explosion Prevention Systems* [DIRS 160953], shall be used for the identification, evaluation, and mitigation of explosive hazards.

Technical Rationale—This criterion is necessary to specify a level of explosion protection system performance that is acceptable in order to limit damage from an explosion. Specification of the capability for the explosion protection system increases the likelihood that an explosion is controlled and mitigated. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.8, which specifies the criteria for explosion protection system performance.

4.8.1.18.2

Criteria—Miscellaneous storage and piping for flammable or combustible liquids or gases shall not create a potential exposure hazard to SSCs ITS or to the fire protection systems that serve those areas of concern. Processes that may evolve hydrogen or explosive gases shall be designed to prevent development of explosive mixtures by limiting the concentration of explosive gases and vapors within enclosures to less than 50 percent of their lower explosive limit.

Technical Rationale—This criterion is necessary to specify a level of explosion protection system performance that is acceptable in order to limit damage from an explosion. Specification of the capability for the explosion protection system increases the likelihood that an explosion is controlled and mitigated before unacceptable damage occurs to SSCs. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.8, which specifies the criteria for explosion protection system performance.

4.8.1.18.3

Criteria—If the potential for an explosive mixture of hydrogen and oxygen exists in off gas systems, the systems shall either be designed to withstand the effects of a hydrogen explosion or be provided with dual automatic control functions to preclude the formation or buildup of explosive mixtures.

Technical Rationale—This criterion is necessary to specify a level of explosion protection system performance that is acceptable to the NRC in order to limit damage from an explosion. Specification of the capability for the explosion protection system increases the likelihood that an explosion is controlled and mitigated before unacceptable losses are incurred. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.8, which specifies the criteria for explosion protection system performance.

4.8.1.19 Fire Barrier System

4.8.1.19.1

Criteria—New permanent structures in excess of a 5,000 sq ft floor area shall be of noncombustible or fire resistive construction.

Technical Rationale—This criterion is necessary to specify performance for building construction type, which would otherwise not meet the improved risk criteria, which is acceptable to the DOE and will limit damage from fires. Specification of a building construction type will increase the likelihood that fire hazards are limited and controlled. This criterion implements DOE O 420.1A [DIRS 159450] and DOE-STD-1066-99 [DIRS 154954], Section 5.2.1, which specify the criteria for building construction type when other criteria are not otherwise specified.

4.8.1.19.2

Criteria—Fire areas shall be separated from other portions of a building or facility (other fire areas) by suitable fire barriers, including suitably rated components of construction such as beams, joists, columns, penetration seals or closures, fire doors, and fire dampers. Fire barriers in buildings containing SSCs ITS shall define a fire area boundary and have a minimum fire resistance rating of three hours. Exterior walls forming a portion of a fire area boundary may be unrated if there is no fire exposure or other over-riding requirement to the wall that would otherwise require the wall to be rated. The construction and performance of fire barrier walls and firewalls shall comply with NFPA 221-2000 [DIRS 160949].

NOTE: Fire zones (fire area subdivisions) may be used to establish zones within fire areas where subdivision into other fire areas is not practical; fire zones shall be based on fire hazard analyses. Fire zone boundaries are usually not sufficient to protect from exposure fires within the same fire area.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and does not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.2, which specifies the criteria for fire area construction and compartmentation.

4.8.1.19.3

Criteria—Fire areas shall be established in the fire hazards analysis. Fire areas shall be defined to separate SSCs ITS from potential fires in other areas containing non-SC SSCs that could affect the ability of SSCs ITS to perform their safety function.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.2, which specifies the criteria for fire area construction and compartmentation.

4.8.1.19.4

Criteria—Fire areas shall be defined to the extent feasible to isolate fire hazards from SSCs ITS in order to limit damage from a single fire. Separate fire areas shall be employed to limit the spread of fires between similar SSC components, including those configurations where high concentrations of cables serve other components of the same respective SSC.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between different components of the same SSC from a given fire hazard. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area, will limit the scope of damage to a given SSC, and will not extend to involve additional components of the same SSC. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.2, which specifies the criteria for fire area construction and compartmentation.

4.8.1.19.5

Criteria—Where fire area boundaries are not three-hour rated or not continuous from boundary to boundary with all penetrations sealed equal to the required fire rating of the boundary, an evaluation shall be performed to assess the adequacy of the fire area boundary. This evaluation shall determine whether the fire area boundaries are adequate to withstand the hazards associated with the area and, as necessary, protect SSCs ITS in the area from a fire originating outside the area. Said evaluation shall be referenced or made part of the fire hazards analysis for the area of concern. Unsealed openings shall be identified and considered when evaluating the overall effectiveness of the barrier. If a fire area boundary contains major unprotected openings, such as hatchways or stairways, locations on either side of such a boundary shall be considered as part of a single fire area.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 1.8.7 and 4.1.2.1, which specify the criteria for fire area construction and compartmentation.

4.8.1.19.6

Criteria—Exterior walls, including any penetrations, shall be qualified as rated fire barriers if they are required to protect SSCs ITS on the interior of the facility from in situ hazards located in the vicinity of the exterior wall. The exterior yard area (without fire barriers) shall be considered as one fire area, though it may consist of several fire zones. The surrounding native terrain and vegetation, considering the degree of spatial separation, shall also be evaluated for fire hazards to site SSCs.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between onsite fire areas and any offsite fire hazard exposure. Specification of this fire area parameter increases the likelihood that an exterior exposure fire is prevented from breaching the exterior fire area boundaries and will not extend to involve SSCs within the building. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.2.1, which specifies the criteria for fire area construction and exposure to fire area boundaries.

4.8.1.19.7

Criteria—Building design shall ensure that openings through fire barriers are properly protected. Openings and penetrations through fire barriers that serve as fire area boundaries shall be appropriately sealed or protected to provide a minimum fire resistance rating equal to that required of the barrier. The construction and installation techniques for rated penetrations and openings through fire barriers shall be qualified by fire endurance tests conducted by nationally recognized laboratories. Structural steel whose sole purpose is to carry dynamic loads from a seismic event need not be protected solely to meet fire barrier criteria, unless the failure of any structural steel member owing to a fire could result in significant degradation of the fire barrier.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections 2.1.4, 4.1.2.1, 4.1.2.2, 4.2.1, 4.2.1.4, 4.2.2, and Appendix A and A-2, which specify the criteria for fire area construction and compartmentation.

4.8.1.19.8

Criteria—Fire barrier walls that also act as part of a radioactive material confinement structure shall be able to withstand the worst case fire condition assuming a loss of any active fire suppression systems within the fire area. For Subsurface Area Barriers, see Section 4.8.1.9.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit fire damage and maintain confinement during a worst case fire exposure condition. Specification of this fire barrier performance increases the likelihood that a fire is prevented from breaching the fire area boundary and will not result in the loss of confinement for the structure. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.1.2.1, which specifies the criteria for fire area construction.

4.8.1.19.9

Criteria—Ventilation fire dampers shall be installed in ducts at fire barrier penetrations with a minimum fire rating of two hours or greater. Fire damper specifications shall include parameters to ensure satisfactory closure performance that addresses the total worst-case differential pressures at the damper under airflow conditions.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.2.1.3, which specifies the criteria for fire dampers used to maintain compartmentation.

4.8.1.19.10

Criteria—Fire barrier penetrations that also function as environmental isolation, pressure differential, or airborne radiation barriers shall be qualified by test to maintain barrier integrity under such conditions.

Technical Rationale—This criterion is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section 4.2.1.4, which specifies the criteria for fire area construction and compartmentation.

4.8.1.19.11

Criteria—Fire barriers in non-nuclear buildings and areas shall comply with the criteria as stated for nuclear buildings, except that fire area boundaries shall have a minimum fire rating of two hours. In addition, separate evaluations are not required to justify exceptions to stated criteria; exceptions may be directly cited and justified in the fire hazards analysis for the area of concern.

Technical Rationale—This criterion is necessary to specify that the system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety and property protection. Passive fire protection features with adequate fire protection system performance will provide acceptable life safety for facility occupants and property protection to meet DOE criteria. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2; DOE G 440.1-5 [DIRS 144423], Section IV, Paragraph 4.0; and DOE-STD-1066-99 [DIRS 154954], Section 9, which specify the criteria for the minimum level of passive fire protection system performance to demonstrate that facility occupants and property are adequately and appropriately protected from fire hazards.

4.8.2 Surface Heating, Ventilation, and Air Conditioning Design Criteria

4.8.2.1 Surface Heating, Ventilation, and Air Conditioning Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Mechanical	Surface Nuclear HVAC/Surface Industrial HVAC[b]	ACGIH 2001, ACGIH 2005, ACI 349-01-2001, ANSI/AMCA 210-99, ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/ASHRAE 33-2000, ANSI/ASHRAE 52.1-1992, ANSI/ASHRAE 55-2004, ANSI/ASHRAE 62.1-2004, ANSI/ASHRAE/IESNA Std 90.1-2004, ANSI/HPS N13.1-1999, ANSI/UL-555-2001, ARI Std 410, ASHRAE 2001, ASHRAE 2003, ASHRAE 2004, ASHRAE 2005, ASHRAE 111-1988, ASHRAE DG-1-93, ASME AG-1-2003, ASME N509-1989, ASME N510-1989, ICC 2000 [DIRS 159179], IEEE Std 323™-2003, IEEE Std 379-2000, IEEE Std 484™-2002, IEEE Std 603-1998, NFPA 801-2003, NFPA 90A-2002, SMACNA 1985, SMACNA 1995, UL 586-2000, UL 900-1999
		NUREG-0800 (NRC 1987), Regulatory Guide 1.140, Regulatory Guide 1.52, Regulatory Guide 1.89, Regulatory Guide 3.32, Regulatory Guide 5.65, Regulatory Guide 8.8
		10 CFR Part 20, 10 CFR Part 63, 10 CFR Part 73, 29 CFR Part 1910, 64 FR 30851
		DOE O 430.2A, DOE O 440.1A, DOE O 450.1, DOE-HDBK-1169-2003, DOE-STD-1027-92, DOE-STD-1066-99, DOE-STD-3020-97

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, the surface nuclear HVAC system, and the surface industrial HVAC system. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This NUREG has been determined to be useful to the development of design products for the preliminary design. These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides. Addressing these regulatory guides supports compliance with requirements for the surface nuclear HVAC system.

[3] Addressing CFRs supports compliance with requirements in PRD-002/T-012, PRD-014/T-022, PRD-015/P-015, PRD-015/P-020 and PRD-021. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] Addressing DOE directives supports compliance with requirements in PRD-018.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

Criteria—The surface facilities of the repository shall be provided with HVAC systems to ensure the indoor design environmental conditions for the health and safety of the facility workers, and shall limit the release of radioactive airborne contaminants for the protection of the public, collocated workers, and the quality of the environment. The surface facilities shall be provided with the following types of HVAC systems:

1. Nuclear HVAC system for the confinement areas of the following waste processing facilities:

    a. Dry Transfer Facility 1 (DTF 1) with integrated Remediation Area
    b. Dry Transfer Facility 2 (DTF 2) with integrated Remediation Area
    c. CHF
    d. FHF.

2. Industrial HVAC system for the following uncontaminated (clean) areas or facilities:

    a. Non-confinement areas of the waste processing facilities (Dry Transfer Facilities with Integrated Remediation Area, CHF, FHF) not served by the nuclear HVAC system such as the support areas and offices, and electrical and HVAC equipment rooms

    b. Cask and Waste Package Receipt Building consisting of the Transportation Cask Receipt/Return Facility and Warehouse and Non-Nuclear Receipt Facility

    c. Miscellaneous Plant Facilities (e.g., Administration Facility, Security Facilities, Utility Facilities, Emergency Response Facilities, Offsite Facilities, Maintenance and Repair Facilities, Materials and Consumable Facilities, BOP Construction Support, and CCCF).

NOTE: The design criteria addressed under the surface nuclear HVAC system (Section 4.8.2.2) shall also be used for the surface industrial HVAC system (Section 4.8.2.3) and ITS HVAC system (Section 4.8.2.4), if applicable, and not addressed specifically in Sections 4.8.2.3 and 4.8.2.4.

Technical Rationale—The HVAC systems have been segregated based on their application to the level of potential for airborne radioactive contamination in the facilities.

4.8.2.2 Nuclear Heating, Ventilation and Air Conditioning System

4.8.2.2.1

Criteria—The nuclear HVAC system shall maintain an indoor environmental condition in accordance with the industry codes and standards. The indoor temperatures shall be based on guidance provided in ANSI/ASHRAE 55-2004 [DIRS 174322]; ANSI/ANS-57.7-1988 [DIRS 102564], Appendix E; ASHRAE 2001, *ASHRAE Fundamentals Handbook* [DIRS 157789]; ASHRAE 2003, *ASHRAE® Handbook, Heating, Ventilating, and Air-Conditioning Applications* [DIRS 171798]; and American Conference of Governmental Industrial Hygienists (ACGIH) guidelines. The humidity and outdoor air ventilation requirement in normally occupied areas shall be in accordance with ANSI/ASHRAE 62.1-2004, *Ventilation for Acceptable Indoor Air Quality* [DIRS 174320]. The indoor environment shall limit concrete surface temperatures in accordance with the requirement of ACI 349-01 [DIRS 158833].

Technical Rationale—This criterion provides appropriate thermal environmental conditions for human occupancy and the safety, health, and comfort of facility workers, as well as proper operation of equipment located inside the facilities. Excessive temperatures in areas where SNF and HLW are handled or staged could cause radiological releases due to the oxidation and unzipping of spent fuel cladding and canister failure and could also cause damage to concrete and other structural materials.

4.8.2.2.2

Criteria—The nuclear HVAC system air handling unit cooling and heating coils shall be designed and sized in accordance with ARI Std 410, *Forced Circulation Air Cooling and Air Heating Coils, with addendum* [DIRS 164310]. The testing shall be performed based on ANSI/ASHRAE 33-2000, *Methods of Testing Forced Circulation Air Cooling and Air Heating Coils* [DIRS 169815].

Technical Rationale—This criterion is based on the general requirement and technical guidelines provided in *ASHRAE Handbook, Heating, Ventilating, and Air-Conditioning Systems and Equipment* (ASHRAE 2004 [DIRS 171799], Chapters 21 and 23) to maintain the required room temperatures and humidity.

4.8.2.2.3

Criteria—The nuclear HVAC system shall be designed based on the meteorological conditions at Mercury, Nevada, or based on the meteorological data collected at the Yucca Mountain site.

Technical Rationale—This criterion establishes the outdoor environmental conditions to be used in the heating and cooling load calculations and establishes a temperature range in which the components of the system are expected to operate in accordance with equipment manufacturer recommendations to ensure the continued operation and readiness of the system. The selection of Mercury, Nevada, as the representative site is appropriate due to its close proximity to the North Portal area. Additional data may be obtained from qualified sources to implement the requirement of the Energy Conservation Program.

4.8.2.2.4

Criteria—The nuclear HVAC system shall, in conjunction with physical barriers, divide and arrange the waste processing facilities into prescribed contamination confinement compartments based on their level of, or potential for, airborne radioactive or hazardous contamination. The confinement zone classification and boundaries shall be based on consideration of the type, quantity, physical and chemical form, and packaging of the nuclear materials handled by the facility.

Technical Rationale—This criterion is in accordance with ASHRAE DG-1-93, *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities*

[DIRS 124644], Section 1; and DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook* [DIRS 167097], Chapter 2. Engineering judgment based on past experience for similar application will be used to determine the preliminary confinement zone boundaries. The final boundaries will be determined during the design process based on area contamination classification.

4.8.2.2.5

Criteria—The nuclear HVAC system shall maintain the differential pressures between the prescribed contamination confinement areas of the facilities in accordance with ASHRAE DG-1-93 [DIRS 124644], Sections 1 and 2; ASHRAE (2003 [DIRS 171798], Chapter 26); and DOE HDBK-1169-2003 [DIRS 167097].

Technical Rationale—The confinement zone classifications, definitions, and pressure requirements described in ASHRAE DG-1-93 [DIRS 124644] are also similarly described in DOE HDBK-1169-2003 [DIRS 167097], Chapter 2.

4.8.2.2.6

Criteria—The nuclear HVAC system shall be designed such that the confinement and non-confinement areas ventilation systems are separate and independent from each other.

Technical Rationale—This criterion is based on the general requirement of designing the ventilation system based on the level of potential for airborne radioactive contamination in accordance with ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.6, and ANSI/ANS-57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)* [DIRS 103093], Section 6.5, to reduce the potential for cross contamination within the facility. This criterion also supports the general requirement in 10 CFR 63.112(e)(1) [DIRS 173273] that requires performance analysis of the SSCs that are ITS to include consideration of a means to limit concentrations of radioactive materials in air. This criterion also supports the performance objective of 10 CFR 63.111(a)(1), which requires the GROA to meet the requirements of 10 CFR Part 20 [DIRS 173165].

4.8.2.2.7

Criteria—The nuclear HVAC system shall provide a once-through cascading (supply air into areas of lesser contamination and exhaust into areas of higher level of contamination) ventilation system to the extent possible equipped with filters, heating coils, cooling coils, and humidifiers (if required) to condition the supply air to the confinement areas of the facilities.

Technical Rationale—This criterion is to ensure that the indoor design environmental conditions are met for the health and safety of the facility workers. This criterion supports the requirements in ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.6.2.2.3.1, and ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.5.1.2, which require that the system with high potential for contamination be designed for once-through flow. This criterion is also based on the general requirement of 10 CFR 63.112(e)(1) [DIRS 173273], which requires performance analysis of the SSCs to include consideration of a means to limit concentrations of radioactive materials in air. This criterion also supports the performance objective of 10 CFR 63.111(a)(1), which requires GROA to meet the requirements of 10 CFR Part 20 [DIRS 173165].

4.8.2.2.8

Criteria—The nuclear HVAC system utilizing the recirculation system for the occupied tertiary and non-confinement areas shall be provided with a minimum quantity of outdoor air in accordance with ANSI/ASHRAE 62.1-2004 [DIRS 174320] to maintain proper indoor air quality for the safety, comfort, and health of the occupational workers in the normally occupied areas.

Technical Rationale—The required outdoor air is to meet the requirements in ANSI/ASHRAE 62.1-2004 [DIRS 174320]. ASHRAE (2005 [DIRS 174692], Chapter 27), states that the conventional air handling systems utilizing the recirculation systems provide approximately 10 to 40 percent outside air fraction of the system airflow rate for ventilation purposes.

4.8.2.2.9

Criteria—The nuclear HVAC supply system shall be comprised of the necessary controls and interlocks, air handling units with filters and coils, supply fans and distribution ductwork, and balancing devices. The nuclear HVAC exhaust system in the confinement areas shall be comprised of the necessary controls and interlocks, exhaust HEPA filter plenums, exhaust fans, ductwork, and balancing devices.

Technical Rationale—This criterion is in accordance with ASME AG-1-2003, *Code on Nuclear Air and Gas Treatment* [DIRS 166908]. This criterion is also in accordance with ASME N509-1989, *Nuclear Power Plant Air-Cleaning Units and Components* [DIRS 115139], and ASME N510-1989, *Testing of Nuclear Air Treatment Systems* [DIRS 115203].

4.8.2.2.10

Criteria—The nuclear HVAC system design utilizing a recirculation system for any contamination confinement area shall include at least one stage of HEPA filters.

Technical Rationale—This criterion is based on ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.6.2.2.2.2, and ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.5.1.2.2, which require filtration of the recirculated air through a HEPA filter unit to prevent buildup of radioactive particulate in the air.

4.8.2.2.11

Criteria—The exhaust HEPA filter plenums shall be provided with the required stages of HEPA filters with a removal efficiency of 99.97 percent on particles measuring 0.3 micrometer or larger, and, if applicable, prefilters and demisters to assist in the removal of airborne radioactive contaminants. The HEPA filters shall have a UL label indicating full compliance with UL-586-2000, *High-Efficiency, Particulate, Air Filter Units* [DIRS 169816].

Technical Rationale—This criterion is based on the general performance requirements of ANSI/ANS-57.7-1988 [DIRS 102564] and ANSI/ANS-57.9-1992 [DIRS 103093], which require the ventilation system to be designed and installed with the capability to collect radioactive airborne particulates during normal operation of the facility. ANSI/ANS-57.7-1988 [DIRS 102564], Sections 6.6.2.2.2.1 and 6.6.2.2.3.1, and ANSI/ANS-57.9-1992 [DIRS 103093], Sections 6.5.1.2.2 and 6.5.1.2.3, require the use of 90 percent prefilters and 99.97 percent HEPA filter banks for the confinement areas.

4.8.2.2.12

Criteria—The nominal size of the HEPA filter shall be in accordance with DOE-STD-3020-97, *Specification for HEPA Filters Used By DOE Contractors* [DIRS 161223], Table 1, and ASME AG-1-2003 [DIRS 166908], Table FC-4000-1. Each HEPA filter shall be 24 in. by 24 in. by 11½ in. with an airflow capacity between 1,000 cfm to 2,000 cfm at a maximum clean filter resistance of 1.3-inch wg. The maximum size of an exhaust HEPA filter plenum shall be limited to 30,000 cfm.

Technical Rationale—This HEPA filter size is based on the standard sizes that are generally used in the nuclear industry. The maximum size of the HEPA filter plenum is based on DOE-HDBK-1169-2003 [DIRS 167097], Section 4.4.11, Regulatory Guide 1.52 [DIRS 171692], Paragraph 3.6, and Regulatory Guide 1.140 [DIRS 158855], Paragraph 3.2.

4.8.2.2.13

Criteria—The nuclear HVAC system shall be designed such that the primary and secondary confinement areas where radioactive contaminants are present shall be provided with an air change frequency of 4 to 8 air changes per hour with up to 30 air changes per hour in the glove boxes. Determination of the actual number of air changes shall be determined during the detailed design process by analyzing the derived air concentration of radioactive particulate matter in the confinement areas and will be compared with the cooling requirements for adequacy.

Technical Rationale—This criterion is based on the general requirement of ASHRAE DG-1-93, *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities* [DIRS 124644], Section 6, and is required for contamination control and to preclude buildup of radioactive contaminants from exceeding ALARA requirements.

4.8.2.2.14

Criteria—The nuclear HVAC confinement exhaust air discharge point for each waste processing facility shall be designed to preclude recirculation of exhaust air into the building intakes for outdoor air.

Technical Rationale—This criterion is required to meet the allowable dispersion requirement. The use of individual building stack will provide flexibility to the modular phase of building construction and its ability to meet the allowable dispersion requirement.

4.8.2.2.15

Criteria—The nuclear HVAC confinement exhaust air discharge point shall be sized for a velocity range of 2,500 to 5,000 ft per minute and minimum height of 12 ft above the highest point of the adjacent building roof line. Where passive (natural) ventilation is used, a separate exhaust discharge point shall be provided and sized at a lower velocity range that will achieve the required flow rate by stack effect.

Technical Rationale—This criterion is based on the recommendation from ASHRAE (2003 [DIRS 171798], Chapter 44). The minimum velocity of 2,500 ft per minute is to provide adequate plume rise and jet dilution. Sizing of the passive discharge point at a lower velocity range will reduce the airflow resistance and achieve the required airflow by stack effect. The minimum discharge point height of 12 ft above the adjacent building roof line is to prevent recirculation of stack effluents into the air intake and to prevent accidental inhalation of potentially contaminated air by the maintenance personnel. Actual discharge height will be determined during the detailed design by analyzing the plume paths and the associated buildings with all systems operating.

4.8.2.2.16

Criteria—The repository vent discharge shall be provided with continuous air emission monitoring system in accordance with ANSI/HPS N13.1-1999, *American National Standard Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities* [DIRS 152380].

Technical Rationale—This criterion is in conformance with ANSI/ANS-57.9-1992 [DIRS 103093], Sections 6.6.2.2.3.4 and 6.5.1.2.3. This criterion ensures that the facility workers are forewarned of unsafe system conditions.

4.8.2.2.17

Criteria—The nuclear HVAC system configuration shall be designed to ensure that occupational doses are ALARA to maintain radiation doses to all occupational workers to below regulatory limits. The design of the system shall be in accordance with the applicable guidelines of Regulatory Guide 8.8 [DIRS 103312] and 10 CFR Part 20 [DIRS 173165].

Technical Rationale—This criterion ensures the continuous operation and readiness of the system to perform its safety function while achieving the occupational ALARA goals during the planning, design, and maintenance and operations phases.

4.8.2.2.18

Criteria—The nuclear HVAC system shall maintain a controlled airflow path directed from areas of low potential for radioactive contamination to areas of higher potential for radioactive contamination. This limits the spread or releases of those airborne radioactive materials and helps to reduce the potential for cross-contamination between areas within the confines of the waste processing facilities.

Technical Rationale—This criterion is based on the general requirement of ASHRAE DG-1-93 [DIRS 124644], Figure 1-1, and in accordance with ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.6.2.1.2, and ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.5.1.1.3.

4.8.2.2.19

Criteria—The nuclear HVAC system design shall have the capability to isolate areas or zones that are subject to contamination by airborne radioactive materials from those that have no potential for contamination by those materials.

Technical Rationale—This criterion is in accordance with ANSI/ANS-57.7-1988 [DIRS 102564], Section 5.6, and ANSI/ANS-57.9-1992 [DIRS 103093], Section 5.5.

4.8.2.2.20

Criteria—The nuclear HVAC system outdoor supply air shall be provided with prefilters and high-efficiency filters to prevent the accumulation of dust or other particulate matter in the facility. Adequate filtration of the air inlet is required to reduce the accumulation of dust on the HEPA filters in the air cleanup units. The efficiency of the prefilters and high-efficiency filters shall be evaluated under ANSI/ASHRAE 52.1-1992, *Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter* [DIRS 164197].

Technical Rationale—This criterion is in accordance with ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.6.2.1, and ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.5.1.1; and DOE-HDBK-1169-2003 [DIRS 167097], which emphasizes the importance of protecting the supply air from the environmental elements.

4.8.2.2.21

Criteria—The nuclear HVAC system shall be provided with all the necessary instrumentation and control hardware that directly operates, controls, monitors, alarms, and provides equipment status required to identify the meaning and significance of the conditions for the functions identified in ASME N509-1989 [DIRS 115139], Tables 4.1 and 4.2, and ASME AG-1-2003 [DIRS 166908], Section IA.

Technical Rationale—This criterion provides a means to monitor and limit the spread or release of radioactive contaminants. It facilitates a prompt termination of operations and permits an evacuation of personnel during an emergency. The instrumentation (with appropriate alarm setpoints) for the air-cleaning units is specified in ASME N509-1989 [DIRS 115139], Section 4.9.2 and Tables 4-1 and 4-2; DOE-HDBK-1169-2003 [DIRS 167097], Section 5.6; and ASME AG-1-2003 [DIRS 166908], non-mandatory Appendix IA-C Section IA.

4.8.2.2.22

Criteria—Ductwork conveying air that is normally contaminated with airborne radioactive contaminants, or the ductwork with great potential for being contaminated by airborne radioactive contaminants, shall be designed to minimize accumulation or trapping of such contaminants, and shall be provided with access doors or hatches at strategic and accessible locations.

Technical Rationale—This criterion is in conformance with the requirements of DOE-HDBK-1169-2003 [DIRS 167097], Section 2.3.8.

4.8.2.2.23

Criteria—The nuclear HVAC exhaust filtration system shall permit periodic inspection, in-place testing, and maintenance of the equipment and components.

Technical Rationale—This criterion is in conformance with the requirements in 10 CFR 63.112(e)(13) [DIRS 173273] and DOE-HDBK-1169-2003 [DIRS 167097], Section 2.3.8.

4.8.2.2.24

Criteria—The nuclear HVAC system shall facilitate the safe decontamination, dismantlement, and removal of SSCs. This criterion specifies general performance requirements to limit radiation doses, the spread of radioactive contamination, and releases of airborne radioactivity.

Technical Rationale—This criterion is in accordance with 10 CFR 63.52 [DIRS 173273].

4.8.2.2.25

Criteria—The nuclear HVAC system and components required to be functional shall be provided with sufficient backup and/or standby units to ensure its continued operation in the event of a failure of any of its components during normal operation, during an event sequence, or during maintenance.

Technical Rationale—This criterion will ensure that the system is capable of operating continuously to protect the personnel from airborne radioactivity. This criterion also meets the requirement of ASHRAE DG-1-93 [DIRS 124644], Section 9.

4.8.2.2.26

Criteria—The nuclear HVAC system design shall include environmental, safety, and health requirements related to personnel safety and OSHA considerations. Included are considerations to minimize noise and confined spaces that may compromise work during component installation, maintenance, and/or replacement. This also ensures that all rotating equipment or moving parts are adequately provided with safety enclosures, guardrails or safety screens, safety disconnect switches, and lighting to protect personnel from accidentally getting caught in the rotating machine during all system operating or maintenance modes.

Technical Rationale—This criterion is in accordance with ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.6.2.1.4, and 29 CFR Part 1910 [DIRS 172709].

4.8.2.2.27

Criteria—The nuclear HVAC system components located within the confines of the facility shall be designed to operate in the expected environmental conditions (temperature and humidity) as well as for expected radiation levels.

Technical Rationale—This criterion establishes the equipment environmental compatibility in accordance with ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.9.2, and ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.8.1.1. These standards state: "System components shall be designed and qualified to operate within environmental limits established for their location within the installation including but not limited to, temperature, humidity, and radiation levels for the applicable performance requirements."

4.8.2.2.28

Criteria—The nuclear HVAC system components located outdoors shall be designed for the maximum wind speed that is specified in Section 6.1. Wind is an environmental parameter that can affect buildings and structures located outside.

Technical Rationale—This criterion shall comply with applicable industry codes and standards to ensure that outdoor components are adequately protected from the wind. The codes and standards also ensure that the system can perform its intended function. Proper consideration of wind is required to ensure that buildings and structures (e.g., plant vent stack) can withstand the wind forces.

4.8.2.2.29

Criteria—The nuclear HVAC system components located outdoors shall be designed to operate in the extreme outdoor (ambient) temperature specified in Section 6.1.

Technical Rationale—The outdoor temperature is an environmental condition that affects component performance or results in their accelerated degradation. This criterion establishes the outdoor temperature range in which the components of the system are expected to operate in accordance with the equipment manufacturer recommendations to ensure the continued operation and readiness of the system.

4.8.2.2.30

Criteria—The nuclear HVAC system components located outdoors shall be designed for an external environment with maximum daily snowfall and precipitation as specified in Section 6.1.

Technical Rationale—This criterion is in accordance with DOE-HDBK-1169-2003 [DIRS 167097], Section 2.3.3, which emphasizes the importance of protecting the supply air intakes from the environmental elements. Similar requirements are invoked in ANSI/ANS-57.9-1992 [DIRS 103093], Sections 6.4.4.1.3 and 6.4.4.1.4. This requirement establishes the snowfall and precipitation conditions in which the components of the system are expected to operate to ensure the continued operation and readiness of the system in accordance with the equipment manufacturer recommendations.

4.8.2.2.31

Criteria—The nuclear HVAC system components located outdoors shall be designed for the ambient relative humidity environment specified in Section 6.1.

Technical Rationale—This criterion is in accordance with DOE-HDBK-1169-2003 [DIRS 167097], Section 2.3.3, which emphasizes the importance of protecting the supply air intakes from the environmental elements. Similar requirements are invoked in ANSI/ANS-57.9-1992 [DIRS 103093], Sections 6.4.4.1.3 and 6.4.4.1.4. This requirement establishes the external environment humidity in which the components of the system are expected to operate to ensure the continued operation and readiness of the system in accordance with equipment manufacturer recommendations.

4.8.2.2.32

Criteria—The nuclear HVAC system air inlet and outlet shall be designed and protected from the effects of the environmental elements (e.g., birds, insects, dust, rain, snow, ashfall, and sandstorms).

Technical Rationale—This criterion is in accordance with DOE-HDBK-1169-2003 [DIRS 167097], Section 2.3.3, which emphasizes the importance of protecting the supply air intakes from the environmental elements. Similar requirements are invoked in ANSI/ANS-57.9-1992 [DIRS 103093], Sections 6.4.4.1.3 and 6.4.4.1.4. This requirement establishes the effect of sandstorms on the air intake systems and outdoor equipment coatings and seals.

4.8.2.2.33

Criteria—The nuclear HVAC system components that provide confinement and filtration of airborne radioactivity, if required, shall be designed and operated to withstand the effects of an earthquake consistent with its safety classification. The nuclear HVAC system shall be designed to remain in place to ensure that the function of SSCs ITS is not affected.

Technical Rationale—This criterion supports the general requirement in 10 CFR 63.112(e)(8) [DIRS 173273], which requires the performance analysis of the SSCs to include consideration of the ability to perform their intended functions, assuming the occurrence of an event sequence.

4.8.2.2.34

Criteria—The nuclear HVAC system components that provide confinement and filtration of airborne radioactivity shall be designed and operated, if required, to withstand the effects of a tornado consistent with its safety classification.

Technical Rationale—This criterion supports the general requirement in 10 CFR 63.112(e)(8) [DIRS 173273], which requires the performance analysis of the SSCs to include consideration of the ability to perform their intended functions, assuming the occurrence of an event sequence.

4.8.2.2.35

Criteria—The nuclear HVAC system design shall ensure that the coating and materials of construction of the system components shall be compatible with other mechanical components, as well as with the waste forms being handled, and any deleterious chemicals resulting from process functions.

Technical Rationale—This criterion complies with ANSI/ANS-57.7-1988 [DIRS 102564], Section 6.6, and ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.5.

4.8.2.2.36

Criteria—The nuclear HVAC system ductwork, air-cleaning units, and components shall be designed, constructed, and supported to remain in-place during normal operation and including an event sequence. The pressure boundary leakage shall be limited to that allowed by the system functional and environmental design requirements.

Technical Rationale—This criterion is in accordance with SMACNA-1995, *HVAC Duct Construction Standards Metal and Flexible* [DIRS 158927]; SMACNA-1985, *HVAC Air Duct Leakage Test Manual* [DIRS 161833]; and ASME AG-1-2003 [DIRS 166908], Section SA and TA.

4.8.2.2.37

Criteria—The design of the nuclear HVAC system shall be in accordance with the physical security criteria applicable to the repository facilities. Physical (security) barriers, if required, shall be provided in the outdoor air intake and exhaust openings to provide delay to forced entry into the protected or restricted areas of the facility.

Technical Rationale—This complies with the requirements of 10 CFR Part 73, Energy: Physical Protection of Plants and Materials [DIRS 173379], and Regulatory Guide 5.65, *Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls* [DIRS 158858].

4.8.2.2.38

Criteria—The nuclear HVAC system shall be tested, balanced, and adjusted in accordance with ASHRAE 111-1988, *Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems* [DIRS 169817].

Technical Rationale—The criteria is in accordance with the requirement specified in ASHRAE (2003 [DIRS 171798], Chapter 37).

4.8.2.2.39

Criteria—The nuclear HVAC system shall be provided with fire protection features to operate in conjunction with the fire rated barriers, fire suppression, fire detection, smoke removal, and fire alarm system. The ductwork penetrating a fire barrier shall be equipped with appropriate fire and smoke dampers to prevent the spread of fire and smoke. The design of the system shall conform to the requirements or recommendation of NFPA 90A [DIRS 160955] and NFPA 801 [DIRS 165077].

Technical Rationale—This criterion is in accordance with the criteria specified in Section 4.8.1, Fire Protection Design Criteria.

4.8.2.3 Industrial Heating, Ventilation, and Air-Conditioning System

NOTE: The design criteria addressed under the surface nuclear HVAC system (Section 4.8.2.2) shall also be used for the surface industrial HVAC system, if applicable, and not addressed specifically in this section.

4.8.2.3.1

Criteria—The industrial HVAC system shall maintain an indoor environmental condition in accordance with industry codes and standards. The indoor temperature shall be based on guidance provided in ANSI/ASHRAE 55-2004 [DIRS 174322]; ANSI/ANS-57.7-1988 [DIRS 102564], Appendix E; ASHRAE (2001 [DIRS 157789]), and ASHRAE (2003 [DIRS 171798]). The outdoor air ventilation and humidity requirement in the normally occupied areas shall be in accordance with ANSI/ASHRAE 62.1-2004 [DIRS 174320]. The indoor environment shall limit concrete surface temperatures in accordance with the requirement of ACI 349-01 [DIRS 158833].

Technical Rationale—This criterion provides appropriate thermal environmental conditions for human occupancy and the safety, health, and comfort of facility workers, as well as proper operation of equipment located inside the facilities. Excessive temperatures in areas where SNF and HLW are staged could cause damage to concrete and other structural materials.

4.8.2.3.2

Criteria—The industrial HVAC system shall be provided with appropriate air handling units equipped with pre-filters and high efficiency filters, heating coils, cooling coils, and humidifiers (if required) to condition the supply air to the non-confinement (clean) areas of the facilities. The cooling coils and heating coils shall be designed in accordance with ARI Std 410 [DIRS 164310]. The efficiency of the prefilters and high efficiency filters shall be in accordance with ANSI/ASHRAE 52.1-1992 [DIRS 164197].

Technical Rationale—This criterion is to ensure that the indoor design environmental conditions are met for the health and safety of the facility workers. Recommended sizing criteria for the filters and coils are described in ASHRAE (2005 [DIRS 174692], Chapter 35, Table 10).

4.8.2.3.3

Criteria—The industrial HVAC system shall be designed based on the meteorological conditions at Mercury, Nevada, or based on the meteorological data collected at the Yucca Mountain site.

Technical Rationale—This criterion establishes the outdoor environmental conditions to be used in the heating and cooling load calculations, and establishes a temperature range in which the components of the system are expected to operate in accordance with equipment manufacturer recommendations to ensure the continued operation and readiness of the system. The selection of Mercury, Nevada as the representative site is appropriate due to its close proximity to the North Portal area. Additional data may be obtained from qualified sources to implement the requirement of the Energy Conservation Program.

4.8.2.3.4

Criteria—The industrial HVAC system utilizing the recirculation system shall be provided with outdoor air of sufficient quantity to maintain proper indoor air quality in accordance with ANSI/ASHRAE 62.1-2004 [DIRS 174320]. A slight positive pressure shall be maintained in the non-confinement (clean) areas relative to atmosphere or adjacent confinement areas.

Technical Rationale—The required outdoor air is to maintain proper air quality for the safety, health and comfort of the occupational workers, and to minimize infiltration of unconditioned air and/or dust during normal operation. ASHRAE (2005 [DIRS 174692], Chapter 27), states that the conventional air handling systems utilizing the recirculation systems provide approximately 10 to 40 percent outside air fraction for ventilation purposes.

4.8.2.3.5

Criteria—The industrial HVAC system design shall be designed such that the normally occupied areas are provided with a circulation air change frequency of 4 to 10 air changes per hour or shall be based on the airflow requirements per square foot area, or as determined by the heating and cooling load calculations and contamination control.

Technical Rationale—This criterion is to provide sufficient air movement in the occupied areas and to maintain proper air quality standards. The range of the air change frequency is based on ASHRAE (2003 [DIRS 171798], Chapter 3).

4.8.2.3.6

Criteria—The industrial HVAC system design shall include environmental, safety, and health requirements related to personnel safety in accordance with 29 CFR Part 1910 [DIRS 172709]. Included are considerations to minimize noise and confined spaces that may compromise work during component installation, maintenance, and/or replacement. The design of the system shall also consider the applicability of the hazard analysis to be performed for the project.

Technical Rationale—This criterion ensures that all rotating equipment or moving parts are adequately provided with safety enclosures, guardrails or safety screens, safety disconnect switches, and lighting to protect personnel from accidentally getting caught in the rotating machine during all system operating or maintenance modes. This criterion will also ensure that the system design will include requirements based on the results of the hazard analysis.

4.8.2.3.7

Criteria—The industrial HVAC system components located within the confines of the facilities shall be designed to operate in the expected environmental conditions (temperature and humidity) as defined in the applicable codes and standards identified in Section 4.8.2.3.1.

Technical Rationale—This criterion establishes the conditions in which the system components are expected to operate in accordance with the equipment manufacturer recommendation to ensure the continued operation and readiness of the system. This criterion also establishes the conditions where the system components performance could be affected as a result of accelerated degradation.

4.8.2.3.8

Criteria—The industrial HVAC system components located outdoors shall be designed for an external environment with maximum daily snowfall, precipitation, and maximum wind speed that is specified in Section 6.1. The system components susceptible to blockage or damage by sand (e.g., air intake system and outdoor units) shall be protected from and designed to operate in sandstorms.

Technical Rationale—This criterion is required to comply with applicable industry codes and standards to ensure that outdoor components are adequately protected from the outdoor environmental hazards and the system can perform its intended function. This criterion establishes the environmental outdoor conditions in which the components of the system are expected to operate to ensure the continued operation and readiness of the system in accordance with the equipment manufacturer recommendations. Wind is an environmental parameter that can affect buildings and structures located outside. Proper consideration of wind is required to ensure that building and structures (e.g., exhaust stack) can withstand the wind forces.

4.8.2.3.9

Criteria—The industrial HVAC system components located outdoors shall be designed to operate in the extreme outdoor (ambient) temperature and relative humidity environment specified in Section 6.1.

Technical Rationale—The outside temperature and relative humidity are environmental conditions that affect component performance or result in their accelerated degradation. This criterion establishes the outdoor thermal conditions in which the components of the system are expected to operate in accordance with the equipment manufacturer recommendations to ensure continued operation and readiness of the system.

4.8.2.3.10

Criteria—The industrial HVAC system shall be designed to include provisions and interfaces to achieve the maximum practicable improvement in efficiency in the use of renewable and clean sources of energy and water conservation.

Technical Rationale—This criterion is in compliance with federal energy and environmental laws and 64 FR 30851, Executive Order 13123, *Greening the Government through Efficient Energy Management* [DIRS 104026] and DOE O 430.2A [DIRS 158913]. Federal buildings and associated building energy-using systems are required to lead to efficient energy management to include greater use of clean and renewable energy sources to comply with the national environmental and energy plans and policies. The energy conservation guidelines are provided in ANSI/ASHRAE/IESNA Std 90.1 2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321].

4.8.2.3.11

Criteria—The industrial HVAC design shall include the required instrumentation and safety devices, control panel, audible alarms and visual displays, and control hardware and software that directly operate, control, monitor, and diagnose the system. The system instrumentation shall be provided with all the necessary alarms and equipment status indication required for the parameters. The required instrumentation shall be provided locally and remotely such that they are readily visible and accessible.

Technical Rationale—The provisions of monitoring, control, and alarm capabilities are integral functional requirements that ensure the proper operation of the system and alarming of unsafe conditions for the protection of the equipment and safety of the occupational workers. The criteria to monitor system performance are in accordance with industry practices.

4.8.2.3.12

Criteria—The industrial HVAC system ductwork and components shall be designed, constructed, and supported to remain in-place during normal operation including an event sequence (if required to support an ITS function). The pressure boundary leakage shall be limited to that allowed by the system functional and environmental design requirements.

Technical Rationale—This criterion is in accordance with SMACNA-1995 [DIRS 158927], SMACNA-1985 [DIRS 161833], and ASME AG-1-2003 [DIRS 166908], Section SA and TA.

4.8.2.3.13

Criteria—The industrial HVAC system shall be provided with fire protection features to operate in conjunction with the fire rated barriers, fire suppression, fire detection, and fire alarm system. The ductwork penetrating a fire barrier shall be equipped with appropriate fire and smoke dampers to prevent the spread of fire and smoke. The design of the system shall conform to the requirements or recommendation of NFPA 90A [DIRS 160955] and also consider the requirements of the Fire Hazard Analysis.

Technical Rationale—This criterion is in accordance with the criteria specified in Section 4.8.1, Fire Protection Design Criteria.

4.8.2.3.14

Criteria—The industrial HVAC systems shall be tested, balanced, and adjusted in accordance with ASHRAE 111-1988 [DIRS 169817].

Technical Rationale—This criterion is in accordance with the requirement specified in ASHRAE (2003 [DIRS 171798], Chapter 37).

4.8.2.3.15

Criteria—The system shall be provided with adequate spares and installed in such a manner to facilitate accessibility for maintenance, repair, replacement, and in-service inspection with consideration under which these activities are to be performed. The system shall be designed to include the permanent features, components, and connections required to perform accurate and reliable inspection and in-place testing of the system and its components.

Technical Rationale—This criterion is required to facilitate inspection, testing, maintenance, repair, and replacement of SSCs as part of an overall reliability, availability, and maintainability program and provide a safe environment for maintenance personnel. This also supports the maintenance activities required to comply with manufacturer recommendations that include periodic calibration, lubrication, and the replacement of components due to wear to avoid system failure and ensure continued system reliability.

4.8.2.4 ITS Portion of the Surface Nuclear and Industrial HVAC Systems

NOTE: The design criteria addressed under the surface nuclear HVAC system (Section 4.8.2.2) shall also be used for the ITS portions of the surface nuclear and industrial HVAC systems, if applicable, and not addressed specifically in this section.

4.8.2.4.1

Criteria—An HVAC system serving the primary confinement zone shall be designed to support the performance objectives of 10 CFR Part 63.111(a) and 10 CFR Part 63.111(b) [DIRS 173273].

Technical Rationale—This criterion ensures that an HVAC system will maintain the areas where radioactive materials are present (e.g., waste transfer cells) at a negative pressure with respect to the atmosphere and adjacent areas. The performance objectives of 10 CFR 63.111(a) and 10 CFR 63.111(b) [DIRS 173273] are to meet the requirements of 10 CFR Part 20 [DIRS 173165] for protection against radiation exposure and releases of radioactive materials.

4.8.2.4.2

Criteria—Areas where radioactive materials are present shall be maintained at the negative pressure during normal operation and following an event sequence.

Technical Rationale—This criterion is required to maintain areas where radioactive materials are present at a negative pressure during normal conditions and event sequences and to ensure that the performance objectives of 10 CFR 63.111(a) and 10 CFR 63.111(b) [DIRS 173273] are met.

4.8.2.4.3

Criteria—ITS HVAC exhaust for areas where radioactive materials are present, including the air-cleaning unit components, shall be designed, constructed, and tested in accordance with the applicable sections of Regulatory Guide 1.52, *Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water Cooled Nuclear Power Plants* [DIRS 171692].

Technical Rationale—This criteria supports the requirements of 10 CFR Part 63.112(e)(1) [DIRS 173273] to provide means to limit concentration of radioactive material in the air.

4.8.2.4.4

Criteria—ITS HVAC exhaust for areas where radioactive materials are present shall be provided with two stages of HEPA filters in order to satisfy the performance objectives of 10 CFR 63.111(a) and (b) [DIRS 173273].

Technical Rationale—This criteria supports the requirements of DOE-HDBK-1169-2003 [DIRS 167097], Section 2.2.9, for two independently testable HEPA filters in exhaust HEPA filter plenums of areas where radioactive materials are present. DOE-STD-1066-99 [DIRS

154954], Section 14.2.4, requires a minimum of two stages of HEPA filters in series in the final filter plenum when the HEPA filters serve as the final means for effluent cleaning.

4.8.2.4.5

Criteria—HVAC systems serving the SNF and canister staging areas shall have sufficient cooling capacity to maintain SNF cladding and canister temperatures below established limits.

Technical Rationale—This criteria supports the performance objective of 10 CFR 63.111(a) and 10 CFR 63.111(b) [DIRS 173273]. HVAC systems are required to ensure that SNF cladding and canister temperatures remain within established limits, to minimize the potential for release of radioactive materials.

4.8.2.4.6

Criteria—The ITS HVAC system design shall consider the single failure event in accordance with Regulatory Guide 1.52 [DIRS 171692], Paragraph C.3.2, and Regulatory Guide 3.32, *General Design Guide for Ventilation Systems for Fuel Reprocessing Plants* [DIRS 103310], Paragraph C.1.c. ITS systems shall be provided with redundant or standby units and components and fail safe control systems in accordance with Regulatory Guide 1.52 [DIRS 171692], Paragraph C.3.1. If redundant units are provided, they shall be physically separated so that damage to one unit does not also cause damage to the redundant unit.

NOTE: Whether redundant or standby units are provided, either must be physically separated so that damage to one unit does not also cause damage to the redundant or standby units.

Technical Rationale—The nuclear regulatory guide endorses IEEE Std 603-1998 [DIRS 125916] and IEEE Std 379-2000 [DIRS 166688] to ensure that ITS systems will continue to perform their safety functions effectively under all conditions. The redundancy requirements described in ASHRAE DG-1-93 [DIRS 124644], Section 9, ensures that a single failure does not result in the loss of capability for the safety system to function properly. Redundancy ensures continuous operation of an ITS HVAC subsystem in the event of the failure of an active component, such as a fan or a damper, during normal operation or an event sequence.

4.8.2.4.7

Criteria—ITS HVAC components shall be designed to withstand the effects of an earthquake (seismic) and remain functional to the extent that it will prevent the uncontrolled release of radioactive materials to the environment in accordance with Regulatory Guide 3.32 [DIRS 103310], Paragraph C.1.k.

Technical Rationale—This criteria supports the requirement of Regulatory Guide 1.52 [DIRS 171692], Paragraph C.3.4, and 10 CFR Part 63.112(e)(8) [DIRS 173273] to provide the ability of the SSCs to perform their intended safety functions, assuming the occurrence of event sequences.

4.8.2.4.8

Criteria—ITS HVAC components shall be environmentally qualified in accordance with the requirements of Regulatory Guide 1.89, *Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants* [DIRS 102609], and IEEE Std 323™-2003 [DIRS 166907].

Technical Rationale—This criterion will ensure that the ITS equipment can perform its safety function during and after an event sequence. This criteria supports the requirement of Regulatory Guide 1.52 [DIRS 171692], Paragraph C.2.1.

4.8.2.4.9

Criteria—The ITS HVAC system shall be designed to withstand tornado conditions without loss of confinement capability resulting from mechanical damage to the system or components or from the reduced ambient pressure at the intake and exhaust openings of the building in accordance with Regulatory Guide 3.32 [DIRS 103310], Paragraph C.1.j. The outdoor air intake and exhaust openings shall also be protected against missiles resulting from a tornado condition.

Technical Rationale—This criteria supports the requirement of 10 CFR Part 63.112(e)(8) [DIRS 173273] to provide the ability of the SSCs to perform their intended safety functions, assuming the occurrence of event sequences

4.8.2.4.10

Criteria—In addition to normal electric power, onsite emergency power shall be provided to operate ITS HVAC systems and components, including instrument and controls, in accordance with Regulatory Guide 3.32 [DIRS 103310], Paragraph C.1.d.

Technical Rationale—This criterion ensures the continuous operation of the HVAC system to perform its safety function.

4.8.2.4.11

Criteria—ITS HVAC systems and components shall be designed to withstand any credible fire and explosion and continue to act as confinement barriers in accordance with Regulatory Guide 3.32 [DIRS 103310], Paragraph C.1.e. An ITS HVAC system shall be capable of operating during a fire in the areas they ventilate and safely handle products of combustion through appropriate ventilation channels. ITS HVAC SSCs shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions.

Technical Rationale—This criteria supports the requirement of Regulatory Guide 3.32 [DIRS 103310], Paragraph C.1.e.

4.8.3 Subsurface Ventilation Design Criteria

4.8.3.1 Subsurface Ventilation Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Mining	Subsurface Ventilation[b]	ACGIH 2005, ACI 349-01, ICC 2000 [DIRS 159179], MIL-STD-1472F, Notice 1 2003
		Regulatory Guide 3.18
		10 CFR Part 63, 29 CFR Part 1910, 29 CFR Part 1926, 30 CFR Part 36, 40 CFR Part 50
		DOE O 440.1A

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21 (c)(2) [DIRS 173273]), PRD-022, and the subsurface ventilation system. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This regulatory guide has been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide. Addressing this regulatory guide supports compliance with requirements for the subsurface ventilation system.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-015/P-020 and PRD-015/P-021. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] Addressing the DOE order supports compliance with requirements in PRD-018.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.8.3.1.1

Criteria—The system shall maintain underground air temperatures in the emplacement drift during normal emplacement operations to be within the industry acceptable range for remotely operated repository equipment. The system shall maintain air temperature in the emplacement drifts at 50°C (122°F) or below during normal emplacement operations (Dorf 1993 [DIRS 125707], p. 786).

Technical Rationale—This requirement is needed to ensure that the subsurface ventilation system provides acceptable underground air temperatures for emplacement equipment operations. *Electrical Engineering Handbook* (Dorf 1993 [DIRS 125707], p. 786) states that the maximum average operational temperature range for most commercial chips is 65°C to 85°C (149°F to 185°F). The 50°C (122°F) value was chosen to provide a safety margin for protection from potential localized fluctuations in temperature near the waste packages.

4.8.3.1.2

Criteria—The subsurface ventilation system design shall take into account potential modes of off-normal system shutdowns and recoveries, such that the drift wall temperatures and air temperatures in the emplacement drifts and downstream airway openings and structures (exhaust mains, shaft and raise connecting drifts, exhaust shafts and raises, shaft and raise collars, and fan pads) do not reach levels that are detrimental to the integrity of structural and ground support components. Maximum temperatures not to be exceeded during off-normal conditions for short duration are as follows (ACI 349-01 [DIRS 158833], Section A.4):

• Exhaust main wall	177°C (351°F)
• Shaft and raise connecting drift wall	177°C (351°F)
• Shaft and raise wall	177°C (351°F)
• Shaft and raise collars	177°C (351°F)
• Fan pads foundations and slabs	177°C (351°F).

Transient maximum temperatures for the emplacement drift wall are limited to 200°C (392°F) and are not related to affects on cementitious materials.

Technical Rationale—Exceedance of stated temperatures for a short duration would compromise the structural integrity of cementitious materials used for ground support and structures in the facilities listed above. Short duration allowance will be determined through calculations during the final design for final design thickness of the concrete, thermal boundary conditions, and location and characteristics of the thermal transient condition. A thermal response curve for the structure will also define potentially lower temperature limits for the structures listed above, to allow for margin below the peak temperature of 177°C (351°F).

4.8.3.1.3

Criteria—Not used.

Technical Rational—Not used.

4.8.3.2 Monitoring Program General Requirements

Criteria—The program shall be implemented so that:

1. It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

2. It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a repository (10 CFR 63.131d [DIRS 173273], 2 and 3).

Technical Rationale—This is to ensure that the subsurface ventilation system includes interface with general requirements of the monitoring program.

4.8.3.3 Contaminant Control General Requirement

Criteria—Whenever hazardous substances such as dusts, fumes, mists, vapors, or gases exist or are produced in the course of construction work, their concentrations shall not exceed the limits specified in the recent edition of ACGIH (ACGIH 2005 [DIRS 173218]) as required by DOE O 440.1A [DIRS 102288]. When ventilation is used as an engineering control method, the system shall be installed and operated according to the requirements of this section.

Technical Rationale—This is to limit the concentration of hazardous substances and to provide acceptable working environmental conditions.

4.8.3.4 General Reference for Threshold Limit Value Limits

Criteria—Exposure of employees to inhalation, ingestion, skin absorption, or contact with any material or substance at a concentration above those specified in the recent edition of ACGIH shall be avoided.

Technical Rationale—This is to limit the concentration of material or substances at working places to meet the standards of the recent edition of ACGIH. Air pollutants may not be vented from the underground facilities without control if such a release will exceed any of the National Ambient Air Quality Standards for carbon monoxide, lead, nitrogen dioxide, ozone, sulfuroxides, and particulate matter in accordance with 40 CFR Part 50 [DIRS 173380].

4.8.3.5 Underground Construction Ventilation Design Parameters

Criteria

1. Ventilation

    a. Fresh air shall be supplied to all underground work areas in sufficient quantities to prevent the dangerous or harmful accumulation of dusts, fumes, mists, vapors, or gases (29 CFR 1926.800(k) [DIRS 172710]).

    b. Mechanical ventilation shall be provided in all underground work areas except when the employer can demonstrate that natural ventilation provides the necessary air quality through sufficient air volume and airflow (29 CFR 1926.800(k) [DIRS 172710]).

2. The direction of mechanical air flow shall be reversible (29 CFR 1926.800(k) [DIRS 172710]).

Volume Per Employee

3. A minimum of 200 cubic ft (5.7 m^3) of fresh air per minute shall be supplied for each employee underground (29 CFR 1926.800(k) [DIRS 172710]).

Drift Velocity

4. The linear velocity of air flow in the tunnel bore, shafts, and all other underground work areas shall be at least 30 ft (9.15 m) per minute where blasting or rock drilling is conducted, or where other conditions likely to produce dust, fumes, mists, vapors, or gases in harmful or explosive quantities are present (29 CFR 1926.800(k) [DIRS 172710]).

Blast Fume Clearing

5. Following blasting, ventilation systems shall exhaust smoke and fumes to the outside atmosphere before work is resumed in affected areas (29 CFR 1926.800(k) [DIRS 172710]).

Ventilation Door Design

6. Ventilation doors shall be designed and installed so that they remain closed when in use, regardless of the direction of the airflow (29 CFR 1926.800(k) [DIRS 172710]).

Dust Control

7. When drilling rock or concrete, appropriate dust control measures shall be taken to maintain dust levels within limits set in the recent edition of ACGIH. Such measures may include, but are not limited to, wet drilling, the use of vacuum collectors, and water mix spray systems. Dust shall be controlled at muck piles, material transfer points, crushers, and on haulage roads where hazards to persons would be created as a result of impaired visibility (29 CFR 1926.800(k)(9) [DIRS 172710]).

Diesel Use

8. Internal combustion engines, except diesel-powered engines on mobile equipment, are prohibited underground per 29 CFR 1926.800(k) [DIRS 172710], stated as follows (30 CFR Part 36 [DIRS 173316]):

> Mobile diesel-powered equipment used underground in atmospheres other than gassy operations shall be either approved by the Federal Mine Safety and Health Act (MSHA) in accordance with the provisions of 30 CFR Part [36] or demonstrated by the employer to be fully equivalent to such MSHA-approved equipment, and shall be operated in accordance with that part. Each brake horsepower of a diesel engine requires at least 100 cubic ft (2.83 m^3) of air per minute for suitable operation in addition to the air requirements for personnel. Some engines may require a greater amount of air to ensure that the allowable levels of carbon monoxide, nitric oxide, and nitrogen dioxide are not exceeded.

Technical Rationale—This is to provide part of the air quality standards and general ventilation requirements for the construction work area. The emplacement area is regulated by the NRC and does not require the reversibility of the ventilation system. The construction area will have reversibility in ventilation, as necessary, to comply with OSHA standards [DIRS 172710]. The OSHA criteria in (6) above related to the design of ventilation doors applies only when the doors are closed, not when the system is designed to keep the doors open or partially open. The OSHA criteria in Section 4.8.3.5(2) does not apply to the emplacement ventilation system. 29 CFR 1926.800 [DIRS 172710] applies to underground construction.

4.8.3.6 Fire Alarm Systems

See Section 4.8.1.

4.8.3.7 Underground Fan Installations

Criteria

1. Fan houses, fan bulkheads for main and booster fans, and air ducts connecting main fans to underground openings shall be constructed of noncombustible materials.

2. Areas within 100 ft (30.5 m) of underground access openings shall be free from stored flammable or combustible materials [29 CFR 1926.800(m) [DIRS 172710].

3. When auxiliary fan systems are used, such systems shall minimize recirculation and be maintained to provide ventilation air that effectively sweeps the working places.

4. Primary or auxiliary fans are provided with appropriate design features and procedures responsive to a fan shutdown or failure to maintain maximum utilization of the ventilation system.

Technical Rationale—This is to provide general guidance for ventilation fan installations.

4.8.3.8 Underground Shops

Criteria—To confine or prevent the spread of toxic gases from a fire originating in an underground shop where maintenance work is routinely done on mobile equipment, one of the following measures shall be taken: use of control doors or bulkheads, routing of the mine shop air directly to an exhaust system, reversal of mechanical ventilation, or use of an automatic fire suppression system in conjunction with an alternate escape route. The alternative used shall at all times provide at least the same degree of safety as control doors or bulkheads.

Technical Rationale—This is to provide general guidance for ventilation fan installations. The alternate measures and decision regarding the use of an automatic fire suppression system in conjunction with an alternate escape route shall be made by the Fire Protection Engineering Group.

4.8.3.9 Exposure Limits for Airborne Contaminants and Exposure Monitoring

Criteria—ACGIH TLVs in the recent edition of ACGIH shall be used for airborne contaminants and exposure monitoring (DOE O 440.1A [DIRS 102288], Section 4.k.1(1)).

Technical Rationale—This is to limit worker exposure to airborne contaminants and provide general guidance for exposure monitoring.

4.8.3.10 Control of Exposure to Airborne Contaminants

Criteria—In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. This shall be feasibly accomplished by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this section (29 CFR 1910.134 [DIRS 172709]).

Technical Rationale—This is to control worker exposure to airborne contaminants by proper ventilation design and controls or by use of protective equipment as the last alternative.

4.8.3.11 Radon Annual Exposure Limits

Criteria—No person shall be permitted to receive a Rn-222 exposure in excess of 4 working level months in any calendar year (29 CFR 1910.1096 [DIRS 172709]).

Technical Rationale—This is to limit the annual radon exposure.

4.8.3.12 Diesel Particulate Regulations

Criteria—Mobile diesel-powered equipment used underground in atmospheres other that gassy operations shall be either approved by MSHA in accordance with the provisions of 30 CFR 57.5060 and 57.5062 [DIRS 173370] or demonstrated by the employer to be fully equivalent to such MSHA-approved equipment, and shall be operated in accordance with the part (29 CFR 1926.800(k)(10)(ii) [DIRS 172710]).

Technical Rationale—This is to provide a basis for limiting worker exposure to the emission of diesel equipment if used in the subsurface facility.

4.8.3.13 Construction, Maintenance, and Use of Ventilation Doors

Criteria

Ventilation doors shall be:

1. Substantially constructed
2. Fire rated as required by the fire hazards analysis (Section 4.8.1)
3. Maintained in good condition
4. Self-closing, if manually operated
5. Equipped with audible or visual warning devices, if mechanically operated.

When ventilation control doors are opened or controlled, they shall be repositioned as soon as possible to re-establish normal ventilation to working places as identified in ventilation models.

Ventilation control measures shall be designed effectively in conjunction with:

1. Control doors
2. Mechanical ventilation reversal (Section 4.8.3.5)
3. Evacuation.

Technical Rationale—This is to provide general guidance for the design, maintenance, and operation of ventilation doors.

4.8.3.14 Ventilation Barriers

Criteria—Subsurface ventilation barriers shall be designed to regulate air leakage from subsurface zones of low potential for contamination to zones of higher potential for contamination.

Technical Rationale—This is to provide a basis for development of ventilation network modeling and planning for various operating stages.

4.8.3.15 Isolation Features

Criteria—Subsurface ventilation systems and components shall have engineered features to prevent leakage of ventilation air from the emplacement area to the development area normally occupied by personnel (Regulatory Guide 3.18 [DIRS 158804]).

Technical Rationale—This is to protect workers in the development area from potential contamination of the emplacement area during simultaneous repository development and waste emplacement operations.

4.8.3.16 Not used

4.8.3.17 NFPA Regulation

Criteria—The subsurface ventilation system shall interface with the fire protection system to ensure that all applicable NFPA standards are properly implemented.

Technical Rationale—This is to ensure that applicable NFPA standards identified in Section 4.8.1.1 of this document are addressed.

4.8.3.18 Human Engineering

Criteria—Subsurface ventilation design shall utilize, where necessary and applicable, MIL-STD-1472F, Notice 1, 2003, *Department of Defense Design Criteria Standard, Human Engineering* [DIRS 170418].

Technical Rationale—This standard establishes general human engineering criteria for the design of systems, equipment, and facilities to (1) achieve required performance by operator, control, and maintenance personnel; (2) minimize skill and personnel requirements and training time; (3) achieve required reliability of personnel-equipment/software combinations; and (4) foster a design standardization within and among systems.

4.8.3.19 Structures

Criteria—Subsurface ventilation related structures shall interface with subsurface structural design and use the IBC (ICC 2000 [DIRS 159179]), wherever applicable.

Technical Rationale—This is to ensure the integration of appropriate structural codes and standards in structural designs that affect subsurface ventilation.

4.8.3.20 System Availability

Criteria—Equipment in the subsurface ventilation system shall be designed with an availability of 0.9825 (about 359 days per year).

Technical Rationale—The requirement ensures the availability of the subsurface ventilation system and is based on engineering judgement consistent with industry operating experience. The PRD (BSC 2003 [DIRS 166275], PRD-022) requires SSCs be designed and fabricated in accordance with applicable industry codes, standards, engineering principles, and practices that incorporate system safety, human factors, reliability, availability, and maintainability.

4.8.4 Site-Generated Radioactive Waste Management Design Criteria

4.8.4.1 Site-Generated Radioactive Waste Management Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Systems	Site-Generated Waste Management[b]	ACGIH 2005, ANSI/ANS-40.35-1991, ANSI/ANS-40.37-1993, ANSI/ANS-55.1-1992, ANSI/ANS-55.4-1993, ANSI/ANS-55.6-1993, ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/IES-RP-7-1991, ASME 2004, ICC 2000 [DIRS 159179], IEEE Std 142-1991, IEEE Std 383™-2003, IEEE Std 80-2000, NFPA 1144-2002, NFPA 70-2004, NFPA 780-2004, NFPA 801-2003, Rea 2000, UL 96A-2001
		Regulatory Guide 1.143, Regulatory Guide 1.189, Regulatory Guide 8.8
		10 CFR Part 20, 10 CFR Part 61, 10 CFR Part 63, 10 CFR Part 71, 10 CFR Part 72, 10 CFR Part 73, 29 CFR Part 1910, 29 CFR Part 1926, 49 CFR Part 172, 49 CFR Part 173, 63 FR Part 49643 (Executive Order 13101)
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (Information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the site-generated waste management system. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-003, PRD-015/P-020, PRD-015/P-021, PRD-021 and PRD-011A. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.
[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

The repository will generate liquid, gaseous, and solid LLW during operations. Handling SNF may result in loose SNF components and elevated levels of contamination. The design and construction of the radioactive waste management systems must provide assurance that radiation exposure to operating personnel and to the general public are in compliance with 10 CFR Part 20 and are ALARA. These systems must also be designed to industry standards to enhance system reliability, operability, and availability.

LLW will be transported to a licensed commercial or government offsite LLW facility for disposal. The LLW disposal location has not been determined and may require following either NRC or DOE requirements depending on the ownership of the site. Once this determination is made, the appropriate orders/regulations will be incorporated in the appropriate documents.

4.8.4.1.1

Criteria—The design of LLW facilities and equipment shall comply with applicable provisions of 10 CFR Part 20 [DIRS 173165].

Technical Rationale—The LLW facilities will handle and store radioactive materials as an NRC licensed facility. The LLW management system will receive, possess, control, transfer, and ship radioactive material while maintaining worker dose ALARA.

4.8.4.2 Classification of LLW Systems for Design Purposes

Criteria—The LLW SSCs shall be classified as described in Regulatory Position 5 and designed in accordance with Regulatory Position 6 of Regulatory Guide 1.143, *Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants* [DIRS 157566].

Technical Rationale—This criterion is required to comply with 10 CFR Part 20 [DIRS 173165]. It presents the position on design of LLW treatment facilities for light water cooled reactor plants, which should be an acceptable approach for this LLW management system.

4.8.4.3 General Design Criteria for LLW Management

4.8.4.3.1

Criteria—To be consistent with the demands of efficiency and cost effectiveness, the design of LLW processing systems and equipment shall consider minimizing the generation of LLW streams prior to recycling, treatment, and disposal.

Technical Rationale—63 FR 49643 [DIRS 104024]) requires, whenever feasible and cost effective, pollution prevention through source reduction prior to recycling, treatment, or disposal.

4.8.4.3.2

Criteria—The process equipment for LLW management systems shall be designed and tested to the requirements set forth in the codes and standards in Regulatory Guide 1.143 [DIRS 157566], Table 1, shown here as Table 4.8.4-1.

Table 4.8.4-1. Codes and Standards for the Design of Low-Level Waste Process Equipment

Component	Design and Construction	Material	Welder and Procedure Qualifications	Inspection and Testing
Piping and Valves	ASME B31.3 [DIRS 158915]	ASME 2004 [DIRS 171846], Sec. II	ASME 2004 [DIRS 171846], Sec. IX	ASME B31.3 [DIRS 158915]
Atmospheric Tanks	API Std 650 [DIRS 164288]	ASME 2004 [DIRS 171846], Sec. II	ASME 2004 [DIRS 171846], Sec. IX	API Std 650 [DIRS 164288] Note 1
Tanks (0-15 psig)	API Std 620 [DIRS 164240]	ASME 2004 [DIRS 171846], Sec. II	ASME 2004 [DIRS 171846], Sec. IX	API Std 620 [DIRS 164240] Note 1
Pressure Vessels and Tanks (> 15 psig)	ASME 2004 [DIRS 171846], Div. 1 or 2	ASME 2004 [DIRS 171846], Sec. II	ASME 2004 [DIRS 171846], Sec. IX	ASME 2004 [DIRS 171846], Sec. VIII, Div. 1 or 2
Pumps	API Std 610 [DIRS 164219]; API Std 674 [DIRS 169819]; API Std 675 [DIRS 169818]; ASME 2004 [DIRS 171846], Sec. VIII, Div. 1 or 2	ASTM A 571/A 571M-01 [DIRS 169820] or ASME 2004 [DIRS 171846], Sec. II	ASME 2004 [DIRS 171846], Sec. IX	ASME 2004 [DIRS 171846], Sec. III, Class 3
Heat Exchangers	TEMA 1999 [DIRS 164215] STD, 8th Edition; ASME 2004 [DIRS 171846], Sec. VIII Div. 1 or 2	ASTM B 359/B 359M-02 [DIRS 169821] or ASME 2004 [DIRS 171846], Sec. II	ASME 2004 [DIRS 171846], Sec IX	ASME 2004 [DIRS 171846], Sec. VIII, Div. 1 or 2

Source: Regulatory Guide 1.143 [DIRS 157566], Table 1.

NOTE 1: Table 1 in Regulatory Guide 1.143 is not correct and shows API Std 620 and API Std 650 reversed. This table shows the correct standards.

Technical Rationale—This criterion establishes design requirements for LLW process equipment. In addition, pipelines and auxiliary facilities necessary to transfer high activity or high hazard LLW to contingency storage will be maintained in an operational condition when waste is present.

4.8.4.3.3

Criteria—The LLW management system shall accommodate waste volumes generated during normal operation as well as those from anticipated maintenance activities. In addition, the system should accommodate solid LLW input for a reasonable period of time when normal shipment of packaged solid LLW from the plant is not possible (i.e., up to 30 days of anticipated normal waste generation) (ANSI/ANS-55.1-1992 [DIRS 122378], Paragraph 8.1).

Technical Rationale—This criterion defines a basis for sizing the LLW management system and provides for a contingency storage capacity.

4.8.4.3.4

Criteria—The LLW waste management SSCs shall be designed to control leakage and facilitate access, operation, inspection, testing, and maintenance in order to minimize radiation exposures to operating and maintenance personnel ALARA.

Technical Rationale—This criterion is required to facilitate compliance with ALARA (Regulatory Guide 1.143 [DIRS 157566], Paragraph 4.1).

4.8.4.3.5

Criteria—To mitigate design basis accidents and control releases of liquids containing radioactive materials, the design and construction of site-generated LLW management systems shall meet the design guidance described in Regulatory Guide 1.143 [DIRS 157566].

Technical Rationale—This criterion is required to facilitate compliance with design guidance acceptable to the NRC in regard to mitigating design basis accidents and controlling releases of liquids containing radioactive materials (e.g., spills or tank overflows).

4.8.4.3.6

Criteria—The solid LLW management system equipment shall not be required to be designed to withstand the effects of a seismic event (ANSI/ANS-55.1-1992 [DIRS 122378], Paragraph 4.2.2.1).

Technical Rationale—This criterion reflects the NRC position on the seismic design of LLW treatment facilities for light water cooled reactor plants, which should be an acceptable approach for this system.

4.8.4.3.7

Criteria—The foundation and walls up to the spill height of the buildings housing LLW management systems shall be designed to the criteria specified in Regulatory Guide 1.143 [DIRS 157566], Paragraph 6.2.

Technical Rationale—This criterion reflects the NRC position on the seismic design of the buildings housing LLW management systems for light water cooled reactor plants, which should be an acceptable approach for this system.

4.8.4.3.8

Criteria—The SSCs of the solid LLW management system shall be designed and tested to the requirements set forth in the codes and standards listed in Regulatory Guide 1.143 [DIRS 157566], Paragraph 3.1.

Technical Rationale—This criterion is required in order to establish a set of accepted codes and standards for the design, construction, materials, welder and welding procedure qualification, and inspection and testing for various categories of mechanical equipment utilized in the LLW management system.

4.8.4.3.9

Criteria—Materials for pressure related components, excluding HVAC ducts and fire protection piping, shall conform to the requirements of the specifications for materials listed in Section II of the ASME Boiler and Pressure Vessel Code, except that malleable, wrought, or cast iron materials and plastic pipe shall not be used (Regulatory Guide 1.143 [DIRS 157566], Paragraph 3.2).

Technical Rationale—This criterion is required to define acceptable materials of construction, including material properties, for pressure containing components of this system.

4.8.4.3.10

Criteria—Pressure-retaining components of process systems shall use welded construction to the maximum practical extent. Flanged joints or suitable rapid-disconnect fittings shall be used only where maintenance or operational requirements clearly indicate such construction is preferable. Screwed connections in which threads provide the only seal shall not be used except for instrumentation, a cast pump body drain, and vent connections where welded connections are not suitable (Regulatory Guide 1.143 [DIRS 157566], Paragraph 4.3).

Technical Rationale—This criterion is required in order to establish a preferred piping connection method for these systems.

4.8.4.3.11

Criteria—Liquid LLW shall be satisfactorily solidified or absorbed using approved absorbent material in sufficient volume to meet the disposal facility's criteria (ANSI/ANS-55.1-1992 [DIRS 122378], Paragraph 4.1.2.1).

Technical Rationale—This criterion identifies a requirement for the solidification or absorption of site-generated liquid LLW.

4.8.4.3.12

Criteria—The LLW SSC design shall incorporate gaseous waste treatment that can filter radioactive particulates from the gas prior to release to the building and ventilation exhaust system (ANSI/ANS-55.1-1992 [DIRS 122378], Paragraph 5.6.5.4).

Technical Rationale—This criterion is required in order to define a gaseous waste treatment strategy.

4.8.4.3.13 Not Used

4.8.4.3.14 Not Used

4.8.4.3.15

Criteria—Packaging and waste form stabilization shall meet the requirements in 10 CFR Part 61, Energy: Licensing Requirements for Land Disposal of Radioactive Waste [DIRS 173313], as well as specific disposal facility requirements (ANSI/ANS 55.1-1992 [DIRS 122378], Paragraph 3.1).

Technical Rationale—This criterion is required to define acceptable packaging and waste form stabilization requirements.

4.8.4.3.16

Criteria—All containers for LLW that will ultimately be disposed of by near-surface disposal shall comply with the requirements of 10 CFR Part 61 [DIRS 173313], Subpart D, Sections 61.55, 61.56, and 61.58. In addition, wastes that are not stabilized are classified B or C and rely on the waste container for stability shall be packaged in the NRC or state approved high integrity containers (ANSI/ANS-55.1-1992 [DIRS 122378], Paragraph 5.9).

Technical Rationale—This criterion identifies the requirements for LLW containers to be used for the disposal of LLW in shallow land burial sites.

4.8.4.3.17

Criteria—LLW shall be packaged and transported in accordance with 49 CFR Part 173 [DIRS 173279].

Technical Rationale—LLW will be packaged in a manner that provides containment and protection until disposal is achieved.

4.8.4.3.18

Criteria—Greater than Class C LLW generated during operations shall be managed in accordance with 10 CFR Part 20 [DIRS 173165] and 10 CFR Part 61 [DIRS 173313].

Technical Rationale—This criterion is required to ensure Greater than Class C LLW that is generated during operations is managed per federal regulation for disposition.

4.8.4.4 Design Criteria for Mobile LLW Processing Systems

4.8.4.4.1

Criteria—The mobile systems used for processing LLW shall be designed and fabricated such that they are capable of being operated in a manner that complies with the requirements specified in ANSI/ANS-40.37-1993, *American National Standard for Mobile Radioactive Waste Processing Systems* [DIRS 164322], Paragraph 3.

Technical Rationale—The purpose of this criterion is to ensure that the mobile LLW processing systems are designed, fabricated, installed, and operated in a manner commensurate with the need to protect the health and safety of the public and plant personnel and the environment.

4.8.4.4.2

Criteria—Mobile LLW processing systems do not have to be designed to withstand the effects of a seismic event. The structures housing the mobile radioactive waste processing equipment shall be designed to contain the fluid inventory of the mobile radioactive waste processing equipment in the event of an operating basis earthquake. In the case where the mobile LLW processing system is not housed in a nuclear facility structure, it shall be designed to prevent a release, as a result of an operating basis earthquake or design basis tornado or hurricane, of liquid or gaseous radioactive material in excess of a small fraction of the limits specified in 10 CFR Part 20 [DIRS 173165] and ANSI/ANS-40.37-1993 [DIRS 164322], Paragraphs 5.3.4 and 5.3.23.

Technical Rationale—This criterion establishes seismic design requirements for mobile LLW processing systems.

4.8.4.4.3

Criteria—Mobile LLW processing equipment and components within the system shall be located, arranged, and shielded to minimize radiation exposure to operating personnel during operation and maintenance (ANSI/ANS-40.37-1993 [DIRS 164322], Paragraph 9.1).

Technical Rationale—This criterion is required to facilitate compliance with ALARA.

4.8.4.5 Design Criteria for High-Level Radioactive Waste Management

4.8.4.5.1 Management of Loose Radioactive Materials

Criteria—Loose radioactive materials (such as fuel debris) resulting from the handling of SNF assemblies shall be managed in accordance with 10 CFR Part 20 [DIRS 173165], 10 CFR Part 72 [DIRS 171253], and 10 CFR Part 73 [DIRS 173379]. Processes and equipment shall be provided for eventual disposal, criticality control, material control and accountability, and safeguards and security. Specific design requirements will be added in a future revision.

Technical Rationale—This criterion is required to ensure that loose radioactive materials resulting from operations are managed per federal regulation for disposition. Examples of loose radioactive materials are residual SNF debris in transportation casks that are removed as necessary, pieces of SNF that result from handling due to lack of fuel element integrity, SNF debris remaining after remediation operations, SNF debris in the remediation pool and its water handling systems, and any other HLW not contained in fuel elements or canisters that occurs as a result of normal, off-normal, or event sequences.

4.8.5 Plant Services System Design Criteria

4.8.5.1 Plant Services System Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Mechanical Utilities	Plant Services System[b]	ANSI Z88.2-1992, ANSI/AWS A5.32/A5.32M-97, ANSI/AWWA C652-02, ANSI/AWWA D100-96, ANSI/AWWA D102-97, ANSI/ISA-S7.0.01-96, API Std 610, API Std 619, API Std 620, API Std 650, API RP 651, ASHRAE 2001, ASHRAE 2004, ASME 2004 (Section IX), ASME 2004 (Section VIII, Div 1), ASME B16.5-1996, ASME B16.5a-1998, ASME B31.3-2002, ASME B73.1-2001, ASTM D 975-04b, Compressed Gas Association 2003, CGA G-10.1-1997, CGA G-11.1-1998, CGA G-7.1-1997, CGA G-9.1-1998, CGA P-18-1992 (Reaffirmed 2003), CGA P-9-2001, CGA V-1-2003, ICC 2000 [DIRS 159180], NAC 445A, NAC 445B, NFPA 20-2003, NFPA 30-2003, NFPA 70-2004, NFPA 780-2004
		NUREG-1536 (NRC 1997)
		29 CFR Part 1910, 40 CFR Part 141, 40 CFR Part 143, Clean Water Act (33 U.S.C. 1251), Safe Drinking Water Act (42 U.S.C. 300f)
		DOE O 420.1A, DOE O 440.1A, DOE O 450.1

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21 (c)(2) [DIRS 173273]), PRD-022, and the plant services system. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This NUREG has been determined to be useful to the development of design products for the preliminary design.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-015/P-020, and PRD-015/P-021.

[4] Addressing DOE directives supports compliance with requirements of PRD-018/P-019. Applicable sections of DOE directives will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

The plant services system consists of the following systems:

- Water
- Fuel oils
- Air (compressed)
- Service gases.

4.8.5.2 Water Supply

4.8.5.2.1

Criteria—Raw well water coming from Nevada Test Site well J-13 and well J-12 with an option of C well complex (wells UE-25c #1 through #3) shall be used for the following purposes: (1) initial supply and make-up to the fire water system; (2) feed the cooling tower supply and makeup; (3) feed the deionized water system; (4) feed the potable water system; and (5) construction water supply.

Technical Rationale—This criterion is required to define the primary sources of raw water supply to the north, south and proposed construction portals. To accommodate estimated future consumption requirement, modifications to the existing well water pumping, tanks, and water line systems may be required. The options of using C wells can be found in "Technical Direction to Bechtel SAIC Company, LLC, Contract Number DE-AC28-01RW12101, Use of J-Wells and C-Wells for Repository Water Sources; TDL No. 04-043" (Arthur 2004 [DIRS 171910]).

4.8.5.2.2

Criteria—The water supply system shall be designed so that essential functions can be performed during normal conditions.

Technical Rationale—This criterion is in accordance with 29 CFR Part 1910 [DIRS 172709]. Where the possibility exists for the eyes or body of any person to be exposed to corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the immediate work area for emergency use.

4.8.5.2.3

Criteria—The potable water system design shall comply with federal and state regulations on public water systems and water quality. The system shall be designed in accordance with Nevada Division of Health, Bureau of Health Protection Services, and NAC requirements, and *Potable Water System Operations and Maintenance Manual* (CRWMS M&O 2000 [DIRS 165475]). Plumbing providing water for human consumption shall be lead-free in compliance with the Safe Drinking Water Act (42 U.S.C. 300f [DIRS 103937]). Potable water shall be chlorinated and treated for arsenic in accordance with *Potable Water System Operations and Maintenance Manual* (CRWMS M&O 2000 [DIRS 165475]) and U.S. Environmental Protection Agency requirements.

Technical Rationale—This criterion is in accordance with 40 CFR Part 141, Protection of Environment: National Primary Drinking Water Regulations [DIRS 173245], and 40 CFR Part 143, Protection of Environment: National Secondary Drinking Water Regulations [DIRS 173351]. The potable water system is designed in accordance with *Potable Water System Operations and Maintenance Manual* (CRWMS M&O 2000 [DIRS 165475]), Nevada Division of Health and NAC requirements, and good engineering practice.

4.8.5.2.4

Criteria—The water quality monitoring system shall have the capability to sample, measure, and analyze physical, chemical, and biological conditions consistent with the requirements of the Clean Water Act (33 U.S.C. 1251 et seq. [DIRS 160406]) and Safe Drinking Water Act (42 U.S.C. 300f [DIRS 103937]) as identified in NAC 445A [DIRS 104040] and NAC 445B [DIRS 104041].

Technical Rationale—This criterion is in accordance with DOE O 450.1 [DIRS 161567]. Such capability must also be compatible with the type and range of concentrations/occurrences of conditions specified by Nevada Division of Health, Bureau of Health Protection Services, NAC 445A [DIRS 104040], NAC 445B [DIRS 104041] requirements, and *Potable Water System Operation and Maintenance Manual* (CRWMS M&O 2000 [DIRS 165475]).

4.8.5.2.5

Criteria—The deionized water shall be required for several operations in the surface facilities. The primary use of deionized water shall be for initial fill and makeup water for the Remediation Area pool. Other deionized water users shall include the waste package decontamination, cask wash down and miscellaneous laboratory applications.

Technical Rationale—A deionized water quality with a conductivity of 0.1 micro-siemens is required for the initial fill of the Remediation Area pool. For all other applications, 1.0 micro-siemens will be used. The requirement is to provide the highest quality of water using the ion exchange system.

4.8.5.2.6

Criteria—The cooling tower water shall provide condenser water to the chillers and shall be designed for an economical pipe size.

Technical Rationale—The function of the cooling tower water system will be to provide evaporative cooling capacity for the chilled water system. Piping will be sized in accordance with the principles outlined in ASHRAE (2001 [DIRS 157789]).

4.8.5.2.7

Criteria—The cooling tower water system supply temperature to the chiller condenser shall be a nominal 85°F with a minimum return temperature differential of 10°F. The cooling tower shall be designed and tested based on the design ambient wet bulb temperature of 69°F. Cooling towers shall be located a sufficient distance from work areas or building intakes to prevent harmful bacteria from entering the workers breathing zones (OSHA 1999 [DIRS 170595]).

Technical Rationale—This criterion is in accordance with accepted industry practices/suggestions as discussed in ASHRAE (2004 [DIRS 171799], Chapters 13 and 36). The design ambient wet bulb temperature is based on the outdoor design condition at Mercury, Nevada, obtained from ASHRAE (2001 [DIRS 157789], Chapter 27, Table 1B). The selection of Mercury, Nevada, as the representative site is appropriate due to its close proximity to the North Portal area.

4.8.5.3 Fuel Oil

4.8.5.3.1

Criteria—Fuel storage tanks shall be designed and located in accordance with applicable regulations and shall be accessible by tank truck and rail. Acceptable fuel storage tanks can also be a concrete vaulted tank that is constructed to a different standard than the large welded tanks.

Technical Rationale—This criterion is in accordance with API Std 650 [DIRS 164288] and NFPA 30-2003 [DIRS 173510].

4.8.5.3.2

Criteria—Diesel fuel N° 2-D (S15) shall be used for equipment requiring diesel fuel.

Technical Rationale—This criterion is in accordance with ASTM D975-04b, *Standard Specification for Diesel Fuel Oils* [DIRS 171651].

4.8.5.3.3

Criteria—Cathodic protection or corrosion control and lightning protection for the fuel oil tanks shall be specified to meet industrial codes.

Technical Rationale—This criterion is in accordance with API RP 651, *Cathodic Protection of Aboveground Petroleum Storage Tanks* [DIRS 166749], and NFPA 780-2004 [DIRS 173517], as applicable.

4.8.5.3.4

Criteria—Fuel oil storage tanks shall be provided with secondary containment to protect from oil spillage and for fire protection.

Technical Rationale—This criterion is in accordance with NFPA 30-2003 [DIRS 173510].

4.8.5.3.5

Criteria—The fuel oil subsystem shall supply diesel fuel No. 2 to the hot water boilers and diesel tanks that support the diesel-driven fire water pumps, diesel-fueled transport vehicles, and diesel generators within the geological repository operations area.

Technical Rationale—This criterion is in accordance with ASTM D975-04b [DIRS 171651].

4.8.5.3.6

Criteria—The diesel tanks for the standby generators shall be sized for not less than 2 hours of full-demand operation of the system.

Technical Rationale—This criterion is in accordance with NFPA 70-2004 [DIRS 172711], Chapter 7, Article 701 III 701.11(B)(2).

4.8.5.3.7

Criteria—The diesel driven fire water pump fuel tanks shall be sized for at least equal to 5.07 L per kW (1 gal per hp), plus 5 percent volume for expansion and 5 percent volume for sump.

Technical Rationale—This criterion is in accordance with NFPA 20-2003 [DIRS 165722].

4.8.5.4 Compressed Air

4.8.5.4.1

Criteria—The function of the breathing air shall be to provide breathing air through hose connections for the purposes of allowing personnel access into the CHF, DTF, and FHF cell areas during normal maintenance or clean-up operation.

Technical Rationale—This breathing air system is designed per the requirements of 29 CFR Part 1910 [DIRS 172709]. The breathing air system is designed to ensure that the delivered air meets or exceeds the CGA G-7.1-1997, *Commodity Specification for Air* [DIRS 164246], Grade D, specification.

4.8.5.4.2

Criteria—The air compressors supplying breathing air to respirators shall be constructed to prevent the entry of contaminated air into the air supply system and have suitable in-line air purifiers, filters, and a carbon monoxide detector to ensure breathing air quality. To maintain operator comfort, the breathing air temperature at the respirator shall be maintained between 45°F and 80°F. A manifold system at each building, which connects to a portable supply system that is filled and purchased from a vendor that certifies the air quality is a viable option.

Technical Rationale—This criterion is in accordance with ANSI Z88-2-1992, American National Standard for Respiratory Protection [DIRS 114614].

4.8.5.4.3

Criteria—The breathing air system shall be provided with a redundant instrumentation system that will provide an indication on the first signal malfunction of the system.

Technical Rationale—This criterion is in accordance with 29 CFR Part 1910 [DIRS 172709].

4.8.5.4.3.1

Criteria—A HEPA filter and pressure regulator at each user connection shall be provided to supply low pressure breathing air.

Technical Rationale—This criterion is in accordance with ANSI Z88.2-1992 [DIRS 114614].

4.8.5.4.3.2

Criteria—The breathing air system and distribution piping shall be independent from the general purpose/instrument air.

Technical Rationale—This criterion is in accordance with 29 CFR Part 1910 [DIRS 172709].

4.8.5.4.4

Criteria—The moisture content of the instrument air is a function of the relative humidity of the ambient air. The pressure dew point as measured at the dryer outlet shall be at least 10°C (18°F) below the minimum temperature to which any part of the instrument air system is exposed. The pressure dew point shall not exceed 4°C (39°F) at line pressure. General purpose/instrument air will be supplied from the same header.

Technical Rationale—This criterion is in accordance with ANSI/ISA-S7.0.01-1996 [DIRS 164287].

4.8.5.4.5

Criteria—Instrument air shall be dry and oil free for the operation of pneumatically controlled instruments.

Technical Rationale—This criterion is in accordance with ANSI/ISA-S7.0.01-1996, *Quality Standard for Instrument Air* [DIRS 164287].

4.8.5.5 Service Gases

4.8.5.5.1

Criteria—The rate of consumption of service gases such as nitrogen, argon, and helium shall be based primarily on the waste-handling schedule. The total waste shipments received in a given year shall be determined by the number of truck and rail shipments.

Technical Rationale—The service gases are provided in a volume sufficient to meet the waste processing schedule provided in the F&OR (Curry 2004 [DIRS 170557], Appendix A, Table 2).

4.8.5.5.2

Criteria—Nitrogen, argon, and helium gases shall be supplied to the North Portal facilities.

Technical Rationale—This criterion is in accordance with the waste package inerting requirement of NUREG-1536 (NRC 1997 [DIRS 101903]). The criterion for inerting the transportation cask and waste package using helium is provided in *Cask and Waste Package Inerting Systems* (BSC 2005 [DIRS 174913]).

4.8.5.5.3

Criteria—Nitrogen, helium, and argon gases shall be at a purity of 99.998, 99.995, and 99.997 percent or greater, respectively.

Technical Rationale—The criterion complies with the minimum specification stated in ANSI/AWS A5.32/A5.32M-97, *Specification for Welding Shielding Gases* [DIRS 160420], Table 1, which also is suitable for transportation casks and systems piping purging or inerting operations.

4.8.5.5.4

Criteria—Helium gas shall be used for inerting the aging casks, transportation casks, and waste packages to minimize the presence of oxidizing gases, predominantly oxygen, evacuated from within the loaded and sealed transportation cask and waste packages.

Technical Rationale—The requirement supports *Cask and Waste Package Inerting System Calculation* (BSC 2005 [DIRS 174913]).

4.8.5.5.5

Criteria—Argon and helium gas shall be blended in a 3/1 (argon/helium) by volume ratio in accordance with ANSI/AWS A5.32/A5.32M-97 [DIRS 160420] for welding the Alloy 22 (UNS N06022) middle and outer lids to the Alloy 22 (UNS N06022) outer corrosion barrier of the waste package.

Technical Rationale—The 3/1 ratio is based on engineering judgement. The welding procedures (including the ratio) are qualified in accordance with ASME (2004 [DIRS 171846], Section III, Subsection NC, and Section IX). The criterion for the volume ratio of the gas blend is in accordance with ANSI/AWS A5.32/A5.32M-97 [DIRS 160420].

4.8.5.5.6

Criteria—Nitrogen gas shall be used for cooling the transportation casks and shall be supplied at a nominal design pressure of 100 psig and at a temperature between 84°F and 100°F.

Technical Rationale—The requirement supports *Cask Cooling System Calculation* (BSC 2005 [DIRS 175034], Section 6.3.1).

4.8.5.6 Control and Monitoring System

Criteria—Instrumentation and control systems shall include provisions to monitor and control the behavior of plant services systems for normal operation. The facilities shall be monitored and alarmed to an oxygen level of 19.5 percent.

Technical Rationale—This criterion is required to define the integral functional requirements of the *Compressed Gas Handbook* (Compressed Gas Association 2003 [DIRS 171615]) that ensure proper operation of the system and the alarming of unsafe conditions to protect the health and safety of occupational workers.

4.8.5.7 System Boundaries Requirements

Criteria—The boundaries of plant services system shall include:

- Identification of various utility services to be provided throughout the surface and subsurface facilities
- Expected utility consumption through review of current project documentation
- Developed design flow rates for the utility services identified
- Sizing of components, systems, and distribution mains using standard engineering calculation techniques.

Technical Rationale—This criterion is required to define the design parameters for each system that needs to be in compliance with the requirements of the applicable codes and standards.

4.8.5.8 System Interfaces Requirements

Criteria—The plant services system shall interface with the surface nuclear and surface industrial HVAC system, fire protection system, DCMIS, electrical power system, non-radiological waste management system, and BOP Facility. The following is a list of interfaces with their associated functions:

- Interface with HVAC plant heating and cooling systems to ensure availability of sufficient raw water and deionized water for the cooling tower and closed loop water system
- Interface with the HVAC surface nuclear and surface industrial systems to ensure availability of instrument air for the operation of pneumatic operated components
- Interface with fire protection system to ensure availability of raw water for adequate fire water supply
- Interface with the digital control and management system to provide status of the system to ensure the proper operation of the system
- Interface with the site electrical power system. The plant services systems shall interface with the normal electric power source with the capability to connect to the standby diesel generators in the event of an electrical outage of the normal power supply. This power supply will ensure proper operation of the plant services system.

- Interface with non-radiological waste management system to provide an environmentally acceptable method for the disposal of cooling tower blow down water and ion exchange bed regeneration neutralized effluent to support operations of the surface facilities.

- Interface with BOP facilities located in the BOP area adjacent to the radiological control area to provide non-radiological support to surface and subsurface operations, including management and administration, warehousing, maintenance, medical, utility (water treatment and compressed air generation), and security.

Technical Rationale—This criterion is required to identify the different interfaces associated with the plant services system. These interfaces are all subjected to the requirements and provision of 29 CFR Part 1910 [DIRS 172709] for the protection of the health and safety of the occupational workers.

4.8.5.9 Piping Requirement

Criteria—The plant services piping system shall be designed in accordance with applicable industry codes and standards.

Technical Rationale—This criterion establishes requirements for the design of plant services piping in accordance with ASME B31.3-2002 [DIRS 158915].

4.8.5.10 Personal Protection Requirement

Criteria—The system design shall include provisions for the protection of the occupational workers during the installation, maintenance, and replacement of SSCs with consideration to rotating equipment, confined spaces, noise barriers, chemical leaks, and respiratory hazards.

Technical Rationale—This criterion is required to ensure that personnel are protected from all rotating equipment by the use of safety guards or safety screens and equipment rooms that provide sensors, alarms, escape provisions, and respiratory protection equipment.

4.8.5.11 Equipment Protection Requirement

4.8.5.11.1

Criteria—The system components located underground and outdoors shall be designed to withstand and operate in the extreme underground and outside temperature environment.

Technical Rationale—This criterion is required for the operational integrity of the system components. Underground and outdoor temperature can affect component performance, equipment degradation (coatings, seals, fluids), and the operation and capability of the system. Interlocks, alarms, access, hazard access, and edge rounding shall be provided and designed in accordance with the applicable requirements of 29 CFR Part 1910 [DIRS 172709].

4.8.5.11.2

Criteria—The system components located outside shall be designed for the extreme outside temperatures identified in Section 6.1.1.5.

Technical Rationale—These values were obtained from ASHRAE (2001 [DIRS 157789], Chapter 26).

4.8.5.12 Testing and Maintenance Requirements

Criteria—The system shall include provisions and features to perform the testing and maintenance of the system and its components essential to safety. The system shall be designed based on a planned maintenance program and the appropriate quantity and type of maintenance spares and supplies required for planned and unplanned maintenance operations.

Technical Rationale—This criterion is required to ensure that the system includes facilities to test intrusion and emergency alarms, physical barriers, and other security-related devices.

4.8.5.13 Not Used

4.8.6 Heating, Ventilation, and Air-Conditioning Plant Heating and Cooling System Design Criteria

4.8.6.1 Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Codes of Federal Regulations (CFRs)[3], DOE Directives[4]
Mechanical	HVAC Plant Heating and Cooling[b]	ANSI/ASHRAE Std 15-2004, ANSI/ASHRAE Std 34-2004, ANSI/ASHRAE/IESNA Std 90.1-2004, ARI Std 550/590-98, ASHRAE 2003, ASHRAE 2004, ASHRAE 2005, ASME 2004, ASME AG-1-2003, ASME B16.3-1998, ASME B31.3-2002, ASME B73.1-2001, ASTM A 234/A 234M-99, ASTM A 53/A 53M-02, AWS D1.1/D1.1M:2002, IEEE Std 1202-1991, NFPA 31-2001
		None
		29 CFR Part 1910, 40 CFR Part 50, 64 FR 30851 (Executive Order 13123), 65 FR 24595 (Executive Order 13148)
		DOE O 430.2A, DOE O 440.1A

Technical Rationale:

[1] These codes and standards support compliance with the requirements of *Projects Requirements Document* (Canori and Leitner 2003 [DIRS 166275]) such as PRD-021/P-001 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022/P-001, and the HVAC plant heating and cooling system. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] None.

[3] Addressing CFRs and executive orders supports compliance with requirements of PRD-015/P-020, PRD-015/P-021, PRD-015/P-027, PRD-022/P-001, PRD-015/P-061, and PRD-018/P-058. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] Addressing these DOE directives supports compliance with the requirements of PRD-015/P-060 and PRD-018/P-021. Applicable sections of these DOE directives will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.8.6.2 Heating, Ventilation, and Air-Conditioning Plant Heating and Cooling System

NOTE: The criteria in this section are not applicable to the direct expansion or evaporative cooling or the use of electric heating to support the Energy Conservation program and economics.

4.8.6.2.1

Criteria—The HVAC plant heating and cooling system shall consist of the chilled water cooling and hot water heating system.

Technical Rationale—The HVAC plant heating and cooling system, in conjunction with the surface nuclear and industrial HVAC systems, is required to ensure that proper environmental conditions are maintained in the surface facilities. The chilled water is provided to the cooling coils for cooling and hot water is provided to the pre-heat and reheat coils for heating. The cooling coils, pre-heat coils, and reheat coils are part of the surface nuclear and industrial HVAC systems.

4.8.6.2.2

Criteria—The HVAC plant heating and cooling water piping system shall be designed in accordance with the applicable industry codes and standards.

Technical Rationale—The criteria establishes the requirement in the design of water piping in accordance with ASME B31.3-2002 [DIRS 158915].

4.8.6.2.3

Criteria—The HVAC plant heating and cooling water piping shall be insulated and shall utilize pipe trenches or pipe racks for distribution throughout the facilities. The piping distribution system shall be designed for economical pipe sizes based on allowable pressure drop, flow rate, and pump selection criteria in accordance with acceptable industry practice and standards.

Technical Rationale—This criterion will ensure that the sufficient water flow is provided to the pre-heat and reheat coils and cooling coils in the surface nuclear and industrial HVAC systems. The performance requirement for the pipe friction loss and water velocity is recommended in ASHRAE (2005 [DIRS 174692], Chapter 36). This criterion will avoid the undesirable effects of high velocities in the piping system (e.g., noise, erosion, and water hammer). Pipe insulation will provide thermal resistance against heat loss or heat gain.

4.8.6.2.4

Criteria—The HVAC plant heating and cooling systems and components shall have provisions to prevent equipment damage during idle periods in cold weather or when subjected to outdoor air condition.

***Technical* Rationale**—The appropriate concentration of glycol in the water systems will ensure freeze protection. This criterion will ensure that the water system is available at all times to the pre-heat coils, reheat coils, and the cooling coils in the surface nuclear and industrial HVAC systems. The selection of glycol and guidelines regarding appropriate concentration is recommended in ASHRAE (2005 [DIRS 174692], Chapter 21).

4.8.6.2.5

Criteria—The HVAC plant heating and cooling systems shall be provided with proper chemical treatment to prevent corrosion.

Technical Rationale—The proper chemical treatment of the chilled and hot water systems will prevent corrosion and hence, will ensure reliability, maintainability, and availability of the systems. The guidelines for water treatment are provided in ASHRAE (2003 [DIRS 171798], Chapter 48).

4.8.6.2.6

Criteria—The HVAC plant heating and cooling systems equipment, components, and piping shall be provided with adequate anchoring and supports in accordance with manufacturer recommendations and industry practices. Adequate flexibility at pipe penetrations to the facilities shall be provided. Floor drains shall be provided in the facilities to handle water leakage from the piping distribution system.

Technical Rationale—This criterion will ensure safety and maintainability of the systems.

4.8.6.2.7

Criteria—The HVAC plant heating and cooling systems shall be designed to include the required instrumentation and safety devices, control panel, audible alarms and/or visual displays, and control hardware and/or software that directly operate, control, monitor, and diagnose the system. The system instrumentation shall be provided with all the necessary alarms and equipment status indication required for the parameters. The required instrumentation shall be provided locally and remotely such that they are readily visible, accessible, and, where feasible, located in the least contaminated area.

Technical Rationale—The provision of monitoring, control, and alarm capabilities are integral functional requirements that ensure the proper operation of the system and alarming of unsafe conditions for the protection of the equipment and safety of the occupational workers. The criteria to monitor the system performance are in accordance with industry practices. The guidelines are provided in ASHRAE (2003 [DIRS 171798], Chapter 46).

4.8.6.2.8

Criteria—The HVAC plant heating and cooling systems shall be designed to include provisions for the protection of the occupational workers with consideration to rotating equipment, confined spaces, and noise barriers. Provisions shall be provided to preclude exposure to the toxic chemical additives used in the chilled and hot water systems.

Technical Rationale—The criterion is required to comply with the applicable codes and standards and provisions of the Environmental, Occupational Safety and Health Regulations and directives. This requirement ensures that all rotating equipment or moving parts be adequately equipped with safety guards or safety screens. The requirements of providing provisions to preclude exposure to the toxic chemical will ensure worker safety.

4.8.6.2.9

Criteria—The HVAC plant heating and cooling systems shall be designed to include provisions and interfaces to achieve the maximum practicable improvement in efficiency in the use of renewable and clean sources of energy and water conservation.

Technical Rationale—This criterion is in compliance with the federal energy and environmental laws and 64 FR 30851, Executive Order 13123, *Greening the Government through Efficient Energy Management* [DIRS 104026] and DOE O 430.2A [DIRS 158913]. Federal buildings and associated building energy-using systems are required to lead to efficient energy management to include greater use of clean and renewable energy sources to comply with the national environmental and energy plans and policies. The energy conservation guidelines are provided in ANSI/ASHRAE/IESNA Std 90.1-2004 [DIRS 174321] and shall be implemented, as required.

4.8.6.2.10

Criteria—The HVAC plant heating and cooling systems shall be provided with adequate spares and installed in such a manner to facilitate accessibility for maintenance, repair, replacement, and in-service inspection. The systems shall be designed to include the permanent features, components, and connection required to perform accurate and reliable inspection and in-place testing of the system and its components.

Technical Rationale—This criterion is required to facilitate the inspection, testing, maintenance, repair, and replacement of the SSCs as part of an overall reliability, availability, and maintainability program. It provides a safe environment for the maintenance personnel. The criteria supports the maintenance activities required to comply with manufacturer recommendations, which include periodic calibration and lubrication. It also supports the replacement of components due to wear to avoid system failure.

4.8.6.2.11

Criteria—The HVAC plant heating and cooling system equipment, components, and instrumentation, such as indicators, recorders, readable display, and gauges, shall be located in accessible areas.

Technical Rationale—This criterion supports the maintainability program.

4.8.6.2.12

Criteria—The HVAC plant heating and cooling systems shall be designed and operated to minimize fire hazards. The system design shall comply with the applicable codes and standards.

Technical Rationale—The criteria is required to comply with the requirements of IEEE Std 1202-1991 [DIRS 160800].

4.8.6.2.13

Criteria—The HVAC plant heating and cooling chilled system components shall be designed and operated to withstand the effect of the applicable environmental conditions.

Technical Rationale—This criterion is required to ensure that the system will perform its intended function.

4.8.6.3 Chilled Water Cooling System

4.8.6.3.1

Criteria—The chilled water cooling system shall be designed to provide sufficient chilled water to the cooling coils of the surface nuclear and surface industrial HVAC systems. The range of the chilled water supply temperature shall be such that it will handle the peak or maximum simultaneous cooling load requirements for the surface facilities.

Technical Rationale—The criterion is required to support the associated HVAC system function to maintain the environmental conditions in the surface facilities. The performance requirements are recommended in ASHRAE (2004 [DIRS 171799], Chapter 11). The standard ratings of supply water temperature and water flow rate per ton of refrigeration are specified in ARI Standard 550/590-98, *Standard for Water Chilling Packages Using the Vapor Compression Cycle, with Addendum* [DIRS 164199], Table 1.

4.8.6.3.2

Criteria—The nominal entering cooling tower (if used) water temperature to the chiller condenser and temperature differential between the condenser leaving and entering water temperature shall be selected to ensure proper operation of the refrigeration system.

Technical Rationale—The standard rating of the condenser entering water temperature and temperature differential will ensure the proper operation of the refrigeration system. This will maintain the proper environmental conditions in the surface facilities. The standard ratings of supply water temperature and water flow rate per ton of refrigeration are specified in ARI Std 550/590-98 [DIRS 164199], Table 1.

4.8.6.3.3

Criteria—The chilled water cooling system design shall utilize environmentally acceptable refrigerant (e.g., R-134a) and be equipped with protective devices to reduce refrigerant loss and minimize refrigerant emissions during service.

Technical Rationale—This criterion complies with the applicable provisions of 65 FR 24595, *Greening the Government Through Leadership in Environmental Management* [DIRS 154538], Executive Order 13148. The safety classification of refrigerants is in accordance with ANSI/ASHRAE Std 34-2004, *Designation and Safety Classification of Refrigerants* [DIRS 174323].

4.8.6.3.4

Criteria—The chilled water cooling system and associated components shall be designed and fabricated in accordance with the applicable standards and codes.

Technical Rationale—The criterion is required to comply with the rules in ASME (2004 [DIRS 171846], Section VIII, Division I). The criteria will prevent or reduce the possibility of harm to personnel caused by pressure vessel failure.

4.8.6.3.5

Criteria—The chilled water system shall be provided with pressure relief protection or any other approved means to safely relieve the system overpressure due to an abnormal operating condition. The pressure relief discharge shall be directed to the atmosphere.

Technical Rationale—The criterion is required to comply with the rules in ASME (2004 [DIRS 171846], Section VIII). The criteria will prevent or reduce the possibility of harm to personnel caused by pressure vessel failure.

4.8.6.3.6

Criteria—The mechanical refrigeration room shall be designed in accordance with applicable codes and standards. In addition, a refrigerant leak detection system and proper ventilation shall be provided for the Mechanical Refrigeration Room for removal of non-condensable gases.

Technical Rationale—The requirements for proper ventilation, the location of a leak detector sensor, alarms, and escape provisions are provided in the ANSI/ASHRAE Std 15-2004, *Safety Standard for Refrigeration Systems* [DIRS 174325]. The refrigerant detector sensors shall be located in areas where refrigerant from a leak will concentrate. The leak detection system shall actuate an alarm and the mechanical purge ventilation system for worker safety.

4.8.6.4 Hot Water Heating System

4.8.6.4.1

Criteria—The hot water heating system shall be designed to provide sufficient hot water to the pre-heat and reheat coils in the surface nuclear and surface industrial HVAC systems at appropriate supply water temperature. The hot water heating system shall be designed for low temperature application, which is an operating temperature of less than 250°F and operating pressure not to exceed 160 psi. The hot water supply temperature shall be such that it will handle the peak or maximum simultaneous heat load requirements for the surface facilities. The range of temperature differential between supply and return water shall be selected for proper control of the hot water heating system and economical pipe sizing.

Technical Rationale—The criterion is required to support the associated HVAC system function to maintain the environmental conditions in the surface facilities. The performance requirement is recommended in ASHRAE (2004 [DIRS 171799], Chapters 11 and 12) for low water temperature system application.

4.8.6.4.2

Criteria—The hot water heating system and associated components shall be designed and fabricated in accordance with applicable standards and codes.

Technical Rationale—The criterion is required to comply with the rules in ASME (2004 [DIRS 171846], Section IV). The criteria will prevent or reduce the possibility of harm to personnel caused by equipment or component failure.

4.8.6.4.3

Criteria—The hot water heating system pressure shall be provided with appropriate pressure relief protection or any other approved means to safely relieve the system overpressure due to an abnormal operating condition.

Technical Rationale—The criterion is required to comply with the rules in ASME (2004 [DIRS 171846], Section IV). This criterion is to prevent or reduce the possibility of harm to personnel caused by overpressurization.

4.8.6.4.4

Criteria—The boiler room shall be provided with the combustion air in accordance with industry standards. The ventilation air shall be provided to maintain proper environmental conditions in the boiler room. The combustion airflow, ventilation airflow, and opening size for combustion air and ventilation air shall be in accordance with industry standards.

Technical Rationale—The combustion air requirement and opening size will ensure proper operation of the boilers. The ventilation air requirement and opening size will ensure that the proper environmental condition is maintained in the boiler room. The criteria for combustion air and ventilation air are provided in NFPA 31-2001, *Standard for the Installation of Oil Burning Equipment* [DIRS 166906], Chapters 5 and 6, respectively.

4.8.6.4.5

Criteria—The hot water boiler shall have provisions to reduce air pollutants such as nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter nominally 10 micrometers or smaller in diameter.

Technical Rationale—This criterion is in compliance with the federal requirements and DOE directives. This requirement is part of the Clean Air Act [DIRS 160411] designed to protect the public health.

4.8.6.4.6

Criteria—The hot water boilers shall be provided with an exhaust stack to convey the products of combustion to a point of safe discharge (atmosphere). The exhaust stack shall be made of noncorrosive material. The stack height shall be determined during detailed design as appropriate.

Technical Rationale—This criterion is required to comply with the national safety standards, building codes and industry practices. The stack material requirement is to prevent corrosion or deterioration of the stack due to condensation. The requirements of stack are recommended in NFPA 31-2001 [DIRS 166906], Chapter 6, and per industry practices.

4.8.7 LLW Generating Systems Design Criteria

4.8.7.1 LLW Generating Systems Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Systems	LLW Generating Systems[b]	ANSI/ANS-40.35-1991, ANSI/ANS-55.1-1992, ANSI/ANS-55.4-1993, ANSI/ANS-55.6-1993, ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/ISA-S84.01-1996, ASME 2004 (Section II[d], Section VIII, Div. 1 or 2 and Section IX; Section III[e] // Section VIII, Div. 1 or Div. 2), ASME B31.3-2002, IEEE Std 383™-2003, NFPA 55-2003, NFPA 70-2004, UL 96A-2001
		Regulatory Guide 1.143, Regulatory Guide 3.20, Regulatory Guide 8.8
		10 CFR Part 20, 10 CFR Part 63, 29 CFR Part 1910, 49 CFR Part 172[f], 63 FR 49643 (Executive Order 13101)
		DOE O 420.1A, DOE O 450.1

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the LLW management system. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing CFRs and the executive order supports compliance with requirements in PRD-015/P-015, PRD-015/P-020, and PRD-021. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] Addressing DOE directives supports compliance with requirements of PRD-014-/T-016. Applicable sections of DOE directives will be determined during the design process in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

[c] Not used.

[d] ASME 2004 [DIRS 171846], Section II required for pressure retaining components.

[e] ASME Code Stamp, material traceability, and the quality assurance criteria of ASME 2004 [DIRS 171846], Section III, Div. 1, Article NCA, are not required. Therefore, these components are not classified as ASME Code Class 3.

[f] 49 CFR Part 172 [DIRS 173350] shall be used as a source of the hazardous materials table.

The LLW generating systems include the following:

- Cask cavity gas sampling
- Cask and waste package inerting
- Cask cooling system
- Spent nuclear fuel assembly drying system

- Pool water treatment and cooling
- Surveying external surfaces of waste packages for radiological contamination
- Decontamination of external surfaces of waste packages
- Decontamination water treatment system.

4.8.7.2 General Design Criteria for LLW Generating Systems

4.8.7.2.1

Criteria—The design of the LLW generating systems shall be safe, efficient, cost effective, and consistent with the goals of ALARA. The design of LLW generating systems shall incorporate source reduction and treatment. Equipment and materials specified by the design will be robust, low maintenance, economical, and fit for purpose.

Technical Rationale—63 FR 49643 [DIRS 104024] requires, whenever feasible and cost effective, pollution prevention through source reduction prior to recycling, treatment, or disposal.

4.8.7.3 Design Criteria for Gaseous Systems

Gas handling systems include:

- Cask cavity gas sampling
- Cask and waste package inerting
- Cask cooling system
- Spent nuclear fuel assembly drying system.

4.8.7.3.1

Criteria—The gaseous systems shall be designed to provide for cask cavity sampling and analysis, cooling, venting, drying, and inerting of cask and waste package cavities as required for the subsequent unloading and shipping of casks or loading and emplacement of waste packages (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.4.2.3.1; ANSI/ANS 57.9-1992 [DIRS 103093], Sections 5.1.4.3 and 6.1.4.1.3).

Technical Rationale—This criterion is required to prepare casks and waste packages for opening and closure. An offgas system will be designed for the collection and treatment of airborne radioactive material that may be contained in the cask cavity on receipt at the facility (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.4.2.3.1).

4.8.7.3.2

Criteria—The gaseous systems design shall provide for radioactive gas collection, condensate removal, air sampling, and chemical monitoring in accordance with Regulatory Guide 3.20 [DIRS 171701], Section B.

Technical Rationale—The gaseous system provides the ability to handle condensable and non-condensable gases generated in process operations and waste storage to limit the release of radioactive materials during normal operations in accordance with the dose limits stated in

10 CFR Part 20 (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.8.2.4). The release of noxious materials will be limited to comply with federal and State of Nevada statutes and implementing regulations in accordance with Regulatory Guide 3.20 [DIRS 171701], Section C.1.b.

4.8.7.3.3

Criteria—The gaseous systems shall be designed (1) to confine hazardous chemicals and radioactive materials evolved during process operations and radioactive waste storage and (2) to maintain offsite doses ALARA.

Technical Rationale—Safe containment, treatment, and disposition of hazardous and radioactive gases and vapor protects workers and the environment from exposure to radioactive material as specified in Regulatory Guide 3.20, *Process Offgas Systems for Fuel Reprocessing Plants* [DIRS 171701].

4.8.7.3.4

Criteria—The gaseous systems shall use stainless steel for process lines and vessels and internals such as filters should be resistant to fire (Regulatory Guide 3.20 [DIRS 171701], Section B).

Technical Rationale—To assure system reliability, the materials used in lines and equipment must be noncombustible, resistant to heat, and resistant to the corrosive effects of the collected gases and the strong chemicals used for equipment decontamination (Regulatory Guide 3.20 [DIRS 171701], Section B).

4.8.7.3.5

Criteria—The design of the gaseous systems shall provide the capability for particulate removal. To prevent potential damage from condensate, filters and adsorbents may be preceded by heaters or by electrical or steam traced lines, which maintain the gas stream above the dew point. It may also be achieved by providing low-point traps and drains on supply headers.

Technical Rationale—Equipment with high collection efficiency is provided to satisfactorily clean gases prior to discharge to the environment (Regulatory Guide 3.20 [DIRS 171701], Section B).

4.8.7.3.6

Criteria—The design of the gas handling systems shall facilitate inspection, maintenance, and testing of systems and components to ensure continued functioning for the life of the facility.

Technical Rationale—This criterion supports the requirement to warrant safe operation of the facility (Regulatory Guide 3.20 [DIRS 171701], Section C.1.f).

4.8.7.3.7

Criteria—The gas handling equipment shall be designed to:

1. Collect gases near points of generation, conduct them in closed piping systems to filters, and vent into the HVAC primary confinement ducting.

2. Prevent header flooding and unsafe accumulation of fissionable materials by sloping the collection piping to drain appropriate process vessels, by use of condensers and knockout pots, and by use of vessel overflow lines.

3. Size vessel vapor lines to provide low gas velocities, provide de-entrainment devices, and separate vessel vent lines from other vessel lines.

4. Operate at negative pressures relative to surrounding cells where practical.

5. Limit the spread of contamination by providing top entry of gas branch lines into headers and by providing pressure relief devices to guard against pressure increases due to flow blockages or gas flows in excess of design specifications.

6. Locate process piping containing radioactive material away from areas frequently occupied by personnel or provide local biological shielding.

Technical Rationale—This criterion provides for protection from radioactive sources in accordance with Regulatory Guide 3.20 [DIRS 171701], Section C.3.

4.8.7.4 Instrumentation, Controls, and Monitoring of Gaseous Systems

4.8.7.4.1

Criteria—The design of the gaseous systems shall include instrumentation, monitoring, and control equipment that provide current indication, to the respective control area, of temperature, pressure, and radiation levels for key points in each gas handling system. Additional instrumentation and indication is provided as required to support the unique requirements of each gas handling system.

Technical Rationale—This criterion supports safe operation of the system by supplying monitoring and control parameters to the operators. For cavity gas sampling, some of these instruments provide indication of seal integrity and the condition of the cask cavity that is required for the safe handling of transportation casks by ANSI/ANS 57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)* [DIRS 103093], Section 6.1.4.1.3.

4.8.7.4.2

Criteria—The sampling system shall provide sampling points for gaseous streams on each cask or waste package testing station and at the process gas discharge points. The sampling system shall provide ports for testing filter efficiency on each safety-related stage of filtration.

Technical Rationale—Instrumentation, controls, and monitoring are designed in accordance with ANSI/ANS 55.4-1993, *Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plants* [DIRS 166935], Section 5.4, and ANSI/ANS 57.9-1992, [DIRS 103093], Section 6.8.1.4.

4.8.7.5 Pool Water System Design

4.8.7.5.1 Pool Water Treatment and Cooling Design Criteria

Criteria—The design of the pool water treatment and cooling system shall:

1. Provide for the removal of dissolved and suspended radioactive material (ANSI/ANS 57.7-1988 [DIRS 102564], Section 3).

2. Ensure that the pool water cooling system (ANSI/ANS 57.7-1988 [DIRS 102564], Section 3) is a closed system capable of recovering from the loss of cooling before bulk boiling of the storage pool water occurs (ANSI/ANS 57.7-1988 [DIRS 102564], Section 5.3).

3. Provide the capability to maintain an annual average gross pool water activity level such that worker dose is maintained ALARA.

4. Provide a method for detecting leakage from the pool (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.1.4).

5. Be designed in accordance with commercial codes as indicated by ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.1.

6. Include equipment for removal of decay heat by an external heat exchanger and for removal of radioactive materials and particulates from the pool water by circulation through filters and ion exchange units. The above system functions can be performed by physically separate systems (ANSI/ANS 57.7-1988 [DIRS 102564], Section 4.3).

7. Maintain an annual average normal pool water operating temperature 90°F or less with a normal pool water operating temperature not to exceed 110°F more than five percent of the time, on the average, during the warmest four consecutive months as determined by the mean wet bulb temperature in accordance with ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.2.

8. Maintain water clarity such that fuel assembly identification can be established by direct viewing through standard underwater viewing devices (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.6.1).

9. To achieve pool water turnover time of 72 hours or less for the purpose of maintaining the pool water gross activity to below limits (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.6.3).

10. Provide for an annual average pool water conductivity less than 3 micro-mho/cm (Johnson 1977 [DIRS 101687]).

11. Ensure that water chloride concentrations shall be less than 0.5 ppm (Johnson 1977 [DIRS 101687]).

12. Ensure that average pool water pH shall be between 5.3 and 7.5 (Johnson 1977 [DIRS 101687]).

13. Provide for control, retention, and disposal of radioactive material removed from the pool water, spent equipment, and material contaminated during operation of the system (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.8).

14. Be able to control water chemistry to maintain fuel assembly cladding and structural member material properties during storage within the pool (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.6.2).

15. Ensure that the piping is designed to eliminate traps, loops and minimize flanges that might accumulate radioactive material (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.10).

16. Avoid the use of built-in crud traps, such as flanged couplings, and dead legs. Construction materials and surface finishes shall be considered to minimize porosity, crevices, and rough machine marks to limit the possibility of tightly adherent contamination, criticality, and to facilitate ease of decontamination (ANSI/ANS 57.7-1988 [DIRS 102564], Section 2.8).

17. Provide for full draining of contaminated piping systems by including the installation of low-point drains, pump drains, tank vent systems, and drain systems, and the elimination of dead legs between valves in system designs (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.10).

18. Consider that radioactive materials may be concentrated or plated out and have provisions in the design to minimize exposure to radiation in its operation and maintenance. Equipment such as ion exchangers and filters shall be individually shielded or located in a shielded cell. In addition, the provision shall be made for isolation and flushing with decontamination solution (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.11).

Technical Rationale—To ensure that the pool water system performance capabilities are maintained in order to prevent the spread of contamination and support normal operations in the pool, the design of the system is in accordance with ANSI/ANS 57.7-1988 [DIRS 102564].

4.8.7.5.2 Pool Water Makeup System

Criteria—The design for the pool water makeup system shall:

1. Provide for a system to compensate for pool water losses (ANSI/ANS 57.7-1988 [DIRS 102564], Section 3).

2. Provide capability to recover from loss of cooling before the design limits of the pool structure are exceeded (ANSI/ANS 57.7-1988 [DIRS 102564], Section 5.3).

3. Provide capability to add deionized water to the storage pool at a rate greater than the loss of pool water by evaporation during normal operations (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.4).

4. Provide capability to maintain minimum water depth (ANSI/ANS 57.7-1988 [DIRS 102564], Section 5.3).

5. Be designed in accordance with commercial codes as indicated by ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.1.1.

6. Be designed to inhibit the escape of contaminated pool water (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.6).

7. Design any piping to eliminate traps, loops, and minimize flanges that might accumulate radioactive materials (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.10).

Technical Rationale—The pool water makeup system is required to maintain the integrity of the pool for the safe management of SNF handling in accordance with the requirements in ANSI/ANS 57.7-1988 [DIRS 102564].

4.8.7.5.3 Testing, Inspection, and Maintenance

Criteria—The design for the pool water treatment and cooling system shall ensure that:

1. Pumps, valves, filters, and other components are readily accessible for maintenance (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.4.1).

2. Filters are capable of being either remotely back flushed or designed so that cartridges can be directly removed into a shielded container (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.4.2).

3. Equipment is provided for periodic functional testing of the pool water cleanup system performance (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.4.3).

4. Instrumentation is provided for periodic functional testing of the heat exchanger(s); i.e., inlet pressure and pressure drop (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.4.4).

Technical Rationale—It is essential that pool water systems be designed to control leakage and facilitate access, operation, inspection, testing, and maintenance in order to maintain radiation exposures to operating and maintenance personnel as low as is reasonably achievable (Regulatory Guide 1.143 [DIRS 157566], Section 4.1).

4.8.7.6 Design Requirements for Surveying for Radiological Contamination of Waste Packages

4.8.7.6.1

Criteria—The following requirements shall apply:

1. The surveying system shall provide for efficient removal of loose radiological contamination from the surface of the waste package.

2. The surveying system shall not damage the waste package surface.

3. The surveying system shall not leave any chemical residue on the waste package surface.

4. The surveying system shall have the capability to be operated remotely.

5. The surveying system equipment shall be robust, easy to repair, reliable with low need for maintenance, and able to disengage and re-engage end effectors and tools remotely.

6. The surveying system shall operate in fail-safe mode and shall not release grip pressure causing tools or materials to be dropped.

7. The surveying system shall be able to withstand up to 100 percent relative humidity, high ambient temperature (up to 150°C at the waste package surface), high intensity ionizing radiation (gamma and neutron), and the presence of fine abrasive dust (present in ambient external atmosphere).

Technical Rationale—The repository will inspect and survey surfaces of sealed waste packages to ensure that the waste package is suitable for emplacement as specified in *Recommended Surface Contamination Levels for Waste Packages Prior to Placement in the Repository* (Edwards and Yuan 2003 [DIRS 164177]).

4.8.7.7 Decontamination of External Surfaces of Waste Packages

4.8.7.7.1

Criteria—The following design requirements shall apply for the decontamination of external surfaces of waste packages:

1. The system shall be capable of decontaminating the waste package to a level such that contamination, worker dose, and environmental releases are maintained ALARA (10 CFR Part 20 [DIRS 173165]).

2. The system shall be designed to control radioactive materials and to minimize radiation exposures to personnel during operation and maintenance. The design shall be consistent with the regulatory requirements in 10 CFR Part 20 [DIRS 173165] and the guidance in Regulatory Guide 8.8 [DIRS 103312].

3. The system shall be designed and tested to the requirements set forth in the codes and standards in Regulatory Guide 1.143 [DIRS 157566], Table 1.

4. The system shall be designed to control leakage and facilitate access, operation, inspection, testing, and maintenance in order to maintain radiation exposures to operating and maintenance personnel as low as is reasonably achievable (Regulatory Guide 1.143 [DIRS 157566]).

5. Piping systems design and testing shall be in accordance with ASME B31.3-2002 [DIRS 158915].

6. Drain pipes shall be designed to minimize traps, loops, and flanges to avoid accumulating radioactive particles (ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.1.3.1.5).

7. Grapples and tools shall be designed to facilitate decontamination, non-destructive testing, maintenance, handling, collection, and remote operation (ANSI/ANS-57.9-1992 [DIRS 103093], Sections 6.2.1.1.5 and 6.2.1.1.11).

8. Design methods and loadings shall be in accordance with ANSI/ANS-57.9-1992 ([DIRS 103093], Section 6.17). The handling equipment may lose its function, but functional failure shall not result in a loss of load incident or inability to recover from the failure (ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.2.1.1.16).

9. SSCs for which operations, maintenance, and required inspections involving exposure to radiation shall be designed, fabricated, located, shielded, controlled, and tested so as to control external and internal radiation exposure to onsite personnel and the public to levels consistent with ALARA principles (ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.13.1).

10. All surfaces of systems for the control and decontamination shall be designed to prevent conditions (such as crevices) where contaminants could accumulate (ANSI/ANS-57.9-1992 [DIRS 103093], Section 6.4.1.10).

Technical Rationale—Decontamination systems will include space and equipment needed for removing radioactive contamination from the exterior of waste packages (ANSI/ANS-57.9-1992 [DIRS 103093], Section 4.1.2).

4.8.7.8 Decontamination Water Treatment System

4.8.7.8.1

Criteria—Design criteria for the decontamination water treatment system shall be as follows:

1. General design requirements for volume reduction of liquid LLW shall be in accordance with ANSI/ANS 40.35-1991 [DIRS 122381].

2. The system design shall provide for treatment of decontamination water, as appropriate, to ensure that the receiving system design limits are not exceeded. These design limits may include requirements for parameters such as pH, conductivity, pressure, temperature, total suspended solids, total organic components, and oil and grease concentration (ANSI/ANS 40.35-1991 [DIRS 122381], Section 9.2).

3. The process and radiation monitoring devices shall be designed to provide continuous monitoring and recording of information about treated liquids (ANSI/ANS-55.6-1993 [DIRS 122354], Section 5.5).

4. The decontamination water treatment system piping (ASME B31.3-2002 [DIRS 158915]) shall be designed to eliminate traps, loops and minimize flanges that might accumulate radioactive material (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.10).

5. The design shall avoid the use of built-in crud traps, such as flanged couplings, and dead legs. Construction materials and surface finishes shall be considered to minimize porosity, crevices, and rough machine marks to limit the possibility of tightly adherent contamination, criticality, and to facilitate ease of decontamination (ANSI/ANS 57.7-1988 [DIRS 102564], Section 2.8).

6. The design shall provide for full draining of contaminated piping systems by including the installation of low-point drains, pump drains, tank vent systems, and drain systems, and the elimination of dead legs between valves in system designs (ANSI/ANS 57.7-1988 [DIRS 102564], Section 6.3.2.10).

7. System equipment and piping shall be designed, constructed, and tested in accordance with requirements in ANSI/ANS-55.6-1993 [DIRS 122354], Table 1.

8. The design for the decontamination water treatment system shall have the ability through tank storage and processing rate to accommodate system liquid volumes (ANSI/ANS-55.6-1993 [DIRS 122354], Section 4.9).

9. Collection tank volumes shall be designed to accommodate the maximum liquid input that occurs for that portion of the day when processing is not available as determined by ANSI/ANS-55.6-1993 ([DIRS 122354], Sections 4.7.3 (b) and (c)). The final tank volumes shall contain an additional 20 percent safety factor and 10 percent freeboard (ANSI/ANS-55.6-1993 [DIRS 122354], Section 4.8).

10. Dikes and retention basins for outdoor liquid storage shall be capable of preventing runoff in case of a tank overflow (ANSI/ANS-55.6-1993 [DIRS 122354], Sections 4.2 and 5.2.1.1).

11. The system is not designed to process decontamination water containing excessive quantities of oil or other organic materials. Specific design measures shall be incorporated to prevent oil or other organic materials from entering the water stream and shall be provided with a means to detect and eliminate such materials from the system during operations (ANSI/ANS-55.6-1993 [DIRS 122354], Section 5.1).

12. Equipment or components of the system shall be selected on the basis of performance requirements, ease of operations, reliability, and ease of maintenance or replacement of components in accordance with ANSI/ANS-55.6-1993 [DIRS 122354], Section 5.1.1.

13. A tank design that eliminates crevices and pockets shall provide for complete drainage. Conical or sloped bottom tanks shall be used (ANSI/ANS 55.1-1992 [DIRS 122378], Section 5.2.2).

14. Sampling of effluent shall be in accordance with applicable provisions of ANSI/ANS-55.6-1993 [DIRS 122354], Section 4.6.

Technical Rationale—This criteria is required to treat and recycle decontamination water to minimize the quantity of liquid LLW generated.

4.8.8 Site-Generated Non-Radiological Waste Management Design Criteria

4.8.8.1 Waste Processing Codes and Standards

Applicable Discipline	SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides /NUREGs[2], Code of Federal Regulations[3], DOE Directives[4]
Waste Systems	Site-Generated Non-Radiological Waste Processing[b]	ICC 2000 [DIRS 159179], IEEE Std 142-1991, IEEE Std 383™-2003, NAC 444, NAC 444A, NAC 519A, NFPA 70-2004, NFPA 780-2004, Rea 2000
		None
		10 CFR Part 20, 29 CFR Part 1910, 29 CFR Part 1926, 30 CFR Part 817, 40 CFR Part 110, 40 CFR Part 112, 40 CFR Part 125, 40 CFR Part 133, 40 CFR Part 136, 40 CFR Part 243, 40 CFR Part 246, 40 CFR Part 257, 40 CFR Part 260, 40 CFR Part 261, 40 CFR Part 262, 40 CFR Part 273, 40 CFR Part 279, 49 CFR Part 172, 49 CFR Part 173, Clean Water Act of 1977 (33 U.S.C. 1251), Pollution Prevention Act of 1990 (42 U. S. C. 13101)

Technical Rationale:

[1] These codes and standards support compliance with requirements of the PRD (Canori and Leitner, 2003 [DIRS 166275]) such as PRD-014/T-013, a limiting condition of operation that does not allow the Resource Conservation and Recovery Act of 1976 (RCRA) [DIRS 103936] waste to be placed in the repository. Applicable sections of these codes and standards will be identified during the design process and in development of design products.

[2] None.

[3] Addressing Code of Federal Regulations supports compliance with requirements for RCRA hazardous waste in PRD-014/T-013, PRD-014/T-016, PRD-015/P-008, PRD-015/P-015, PRD-015/P-020, PRD-015/P-021, PRD-015/P-030, PRD-015/P-070, PRD-015/P-074, and PRD-021/P-001 and 2) non-hazardous waste in PRD-015/P-004, PRD-015/P-013, PRD-015/P-020, PRD-015/P-021, PRD-015/P-032, PRD-015/P-042, PRD-015/P-043, PRD-015/P-065, PRD-015/p-066, PRD-015/P-067, PRD-015/P-069, PRD-015/P-077, PRD-015/P-079, and PRD-015/P-084. Applicable sections of these documents will be identified during the design process and in development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

The repository will generate the following non-radiological waste streams:

- Hazardous wastes comprised of RCRA hazardous wastes
- Non-hazardous wastes comprised of solid and liquid wastes.

The design and construction of site-generated hazardous waste and non-hazardous waste management systems must meet applicable regulatory requirements. These systems must be designed to industry standards to enhance system reliability, operability, and availability.

4.8.8.2 Not Used

4.8.8.3 General Design Criteria for Processing RCRA Hazardous Waste

4.8.8.3.1

Criteria—To be consistent with the demands of efficiency and cost effectiveness, the design of the hazardous waste processing system, equipment, and facilities shall minimize the generation of hazardous waste streams prior to recycling and disposal.

Technical Rationale—The Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq. [DIRS 103930]) requires, whenever feasible and cost effective, pollution prevention through source reduction prior to recycling, treatment, or disposal.

4.8.8.3.2

Criteria—The hazardous waste processing system shall accommodate waste volumes generated during normal operation as well as those from anticipated maintenance activities. In addition, the system should accommodate solid waste input for a reasonable period of time when normal shipment of packaged hazardous solid waste from the repository is not possible (i.e., up to 180 days of anticipated normal waste generation) (40 CFR Part 262 [DIRS 173333]).

Technical Rationale—This criterion defines a basis for sizing of the hazardous waste management system and the Project Accumulation Area (PAA) facilities.

4.8.8.3.3

Criteria—The hazardous waste processing system shall maintain the separation of hazardous, non-hazardous, and low-level radioactive waste (LLW) in order to prevent the generation of mixed waste and minimize the generation of LLW.

Technical Rationale—This criterion sets forth requirements to minimize the amount of waste generated, as well as determine what waste disposal activities pose a reasonable probability of adverse effects on the health and environment (Canori and Leitner 2003 [DIRS 166275], PRD-014/T-016).

4.8.8.3.4

Criterion—The hazardous waste processing system shall take into account the design measures needed to prevent pollution of the environment.

Technical Rationale—This criterion is required to comply with 40 CFR Part 260 [DIRS 173332] and 40 CFR Part 262 [DIRS 173333].

4.8.8.3.5

Criteria—The SSCs of the hazardous waste processing system shall be designed and tested to the requirements set forth in codes and standards for non-SC SSCs listed in the Section 4.2.2.2.

Technical Rationale—This criterion is required in order to establish a set of accepted codes and standards for design, construction, materials, welder and welding procedure qualification and inspection and testing for various categories of mechanical equipment used in the system.

4.8.8.3.6

Criteria—The hazardous waste processing system shall take into account the design measures necessary to implement requirements for the handling of universal waste as outlined in 40 CFR Part 273 [DIRS 173381].

Technical Rationale—This criterion ensures that universal waste requirements are included in the hazardous waste management program.

4.8.8.3.7

Criteria—Provisions shall be made for the collection and accumulation of hazardous waste at or near the point of generation. These areas are known as Satellite Accumulation Areas (SAAs) and are used for the temporary collection of hazardous waste. SAAs shall be located away from areas that may generate or stage LLW in order to prevent the generation of mixed waste. The SAAs shall be clearly marked as hazardous material collection areas.

Technical Rationale—SAAs will meet the requirements of 40 CFR Part 262 [DIRS 173333] for the collection and staging of hazardous material.

4.8.8.3.8

Criteria—Full containers of hazardous waste shall be moved from a SAA to a PAA located away from the generation site. The PAA shall consist of separate facilities to segregate the hazardous waste types for consolidation, staging. and transportation. The PAA shall be furnished with electrical power, heating, ventilation, and air-conditioning. Universal waste handling shall be provided as part of the PAA.

Technical Rationale—The PAA will meet the requirements of 40 CFR Part 262 [DIRS 173333] for the collection, staging, and transportation of hazardous material.

4.8.8.3.9

Criteria—A means shall be provided for obtaining the load weight of hazardous material being transported to a treatment, storage, or disposal facility.

Technical Rationale—Hazardous material being shipped to a treatment, storage, or disposal facility will meet the transportation requirements of 49 CFR Part 172 [DIRS 173350] and 49 CFR Part 173 [DIRS 173279] for providing lading weight for shipping documentation.

4.8.8.4 General Design Criteria for Processing Non-Hazardous Solid Waste

4.8.8.4.1

Criteria—To be consistent with the demands of efficiency and cost effectiveness, the design of non-hazardous solid waste processing system, equipment, and facilities shall minimize the generation of non-hazardous waste streams prior to recycling and disposal.

Technical Rationale—The Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq. [DIRS 103930]), requires, whenever feasible and cost effective, pollution prevention through source reduction prior to recycling, treatment, or disposal.

4.8.8.4.2

Criteria—The SSCs of the non-hazardous solid waste processing system shall be designed and tested to the requirements set forth in codes and standards for non-SC SSCs listed in Section 4.2.2.2.

Technical Rationale—This criterion is required in order to establish a set of accepted codes and standards for design, construction, materials, welder and welding procedure qualification and inspection and testing for various categories of mechanical equipment used in the system.

4.8.8.4.3

Criteria—Design of SSCs for the non-hazardous solid waste processing system shall provide for the handling, collection, and storage of solid waste as provided for in 40 CFR Part 243 [DIRS 173329].

Technical Rationale—This criterion is necessary for the establishment of a non-hazardous solid waste management program that includes processes and procedures, as well as, frequencies for collection of non-hazardous solid waste generated at the repository.

4.8.8.4.4

Criteria—The design of the non-hazardous solid waste processing system shall ensure that the environment is protected in accordance with 40 CFR Part 257 [DIRS 173331].

Technical Rationale—This criterion is required to ensure that solid waste disposal practices are implemented through a program meeting the established design criteria.

4.8.8.4.5

Criteria—The non-hazardous solid waste processing system shall provide for a materials recovery program meeting the applicable provisions of 40 CFR Part 246 [DIRS 173330].

Technical Rationale—This criterion is required to ensure that applicable guidelines, for the separation of materials for recovery, are included in the non-hazardous solid waste management program.

4.8.8.4.6

Criteria—A fenced in area of sufficient size to accommodate the PAA facilities, office facilities and non-hazardous waste processing facilities shall be provided.

Technical Rationale—In accordance with the PRD (Canori and Leitner 2003 [DIRS 166275], PRD-014/T-16), the operating area must be of sufficient size to maintain the separation of site-generated waste streams. The design of the operating area must allow for the segregation of waste types.

4.8.8.4.7

Criteria—Subsurface excavated rock from repository development shall be transported to the surface and stored in appropriate sized excess rock storage piles in the vicinity of the South Portal and the North Construction Portal area.

Technical Rationale—Excess rock from the subsurface requires a disposal site within a reasonable distance from the exit tunnels in order to limit the cost of hauling the material. The excess rock will be placed in a controlled manner to ensure that runoff will not degrade surface or underground water, the fill is stable and designed using standard engineering practices, and pollution controls meet existing regulations. Regulations cited in 30 CFR Part 817 [DIRS 173318] provide guidelines that can be used in the design.

4.8.8.4.8

Criteria—Where feasible, topsoil shall be removed from areas where construction of facilities is designated and placed in topsoil stockpiles in accordance with *Reclamation Implementation Plan* (YMP 2001 [DIRS 154386]).

Technical Rationale—Topsoil is removed and stockpiled to provide material for reclamation in accordance with 30 CFR Part 817 [DIRS 173318] and NAC 519A [DIRS 172702].

4.8.8.5 General Design Criteria for Processing Non-Hazardous Liquid Waste

4.8.8.5.1

Criteria—The SSCs of the non-hazardous liquid waste processing system shall be designed and tested to the requirements set forth in codes and standards for non-SC SSCs per Section 4.2.2.2.

Technical Rationale—This criterion is required in order to establish a set of accepted codes and standards for design, construction, materials, welder and welding procedure qualification and inspection and testing for various categories of mechanical equipment used in the system.

4.8.8.5.2

Criteria—The design for the non-hazardous liquid waste processing system shall meet the requirements of the Clean Water Act of 1977 (33 U.S.C. 1251 et seq. [DIRS 160406]).

Technical Rationale—This criterion is required to ensure that non-hazardous liquid waste systems are designed, installed, and operated in a manner commensurate with the need to protect personnel and the environment.

4.8.8.5.3

Criteria—The design for the non-hazardous liquid waste processing systems shall meet the requirements of the Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq. [DIRS 103930]).

Technical Rationale—This criterion is required to ensure that the design of SSCs for the non-hazardous liquid waste processing systems provides for the development of procedures and programs to emphasize waste minimization and pollution prevention practices.

4.8.8.5.4

Criteria—The design of SSCs for the non-hazardous liquid waste processing systems shall comply with applicable provisions of 40 CFR Part 112 [DIRS 173320].

Technical Rationale—This criterion provides standards imposed in permits for applicable discharge sources.

4.8.8.5.5

Criteria—The design and construction of the sanitary sewage collection system shall comply with the requirements of NAC 444 [DIRS 104039] and Section 4.2.1.3.5.

Technical Rationale—This criterion ensures that the design of the sanitary sewage collection system meets State of Nevada requirements and good engineering practices.

4.8.8.5.6

Criteria—The system for the processing of non-hazardous liquid wastes shall provide provisions for treatment of secondary wastewater as regulated by 40 CFR Part 136 [DIRS 173328].

Technical Rationale—This criterion ensures that applicable procedures are developed and implemented for the control and treatment of effluent pollutants in secondary wastewater.

4.8.8.5.7

Criteria—Non-hazardous liquid waste processing systems shall be designed to minimize oil pollution of the environment and comply with applicable provisions of 40 CFR Part 112 [DIRS 173320].

Technical Rationale—This criterion ensures that the design of the SSCs required for the processing of non-hazardous liquid wastes adequately identify the procedures, methods, and equipment to prevent, control and contain discharge of oil from related facilities.

4.8.8.5.8

Criteria—All disturbed surface areas of the repository shall be designed to accommodate storm water run-off depending on the functional requirements of the associated facility. Design requirements shall be in accordance with Section 4.2.1.3.6.

Technical Rationale—Storm water run-off will be controlled in accordance with the Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq. [DIRS 103930]) and 30 CFR Part 817 [DIRS 173318].

4.8.8.5.9

Criteria—Wastewater evaporation ponds shall be constructed to contain wastewater generated by surface and subsurface operations. The evaporation ponds shall be constructed with impermeable liners, where warranted, to prevent wastewater percolation into the underlying ground water system. Evaporation ponds shall be constructed in accordance with requirements to be developed in Section 4.2.1.3.

Technical Rationale—Wastewater will be controlled in accordance with the Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq. [DIRS 103930]).

4.8.8.6 General Design Criteria for Processing Non-Radiological Recyclable Waste Streams

4.8.8.6.1

Criteria—Non-radiological waste handling facilities shall provide for the processing of recyclable solids and liquids that are removed from the waste stream and shipped to commercial recyclers.

Technical Rationale—In accordance with the policy stated in the Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq. [DIRS 103930]), recyclables will be separated from the non-hazardous waste stream as a matter of practice according to the provisions in NAC 444 [DIRS 104039], NAC 444A [DIRS 166414], and 40 CFR Part 246 [DIRS 173330].

4.9 NUCLEAR DESIGN CRITERIA

4.9.1 Nuclear Engineering Design Criteria

4.9.1.1 Nuclear Engineering Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Nuclear Engineering	Nuclear Engineering[b]	ANSI N13.8-1973, ANSI N305-1975, ANSI/ANS-57.1-1992, ANSI/ANS-57.9-1992, ANSI/ANS-59.3-1992, ANSI/ANS-6.1.1-1977, ANSI/ANS-6.4-1997, ANSI/ANS-6.4.2-1985, ASTM C 1217-00, ASTM C992-89 (Reapproved 1997), IEEE Std 323™-2003
		Regulatory Guide 1.109, Regulatory Guide 1.143, Regulatory Guide 1.145, Regulatory Guide 3.71, Regulatory Guide 8.10, Regulatory Guide 8.25, Regulatory Guide 8.34, Regulatory Guide 8.38, Regulatory Guide 8.5, Regulatory Guide 8.8
		10 CFR Part 20, 10 CFR Part 61, 10 CFR 63.111(a), 10 CFR 63.111(b), 10 CFR 63.204, 10 CFR Part 71, 49 CFR Part 173
		DOE-HDBK-1169-2003

Technical Rationale:

[1] These codes and standards support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21 (c)(2) [DIRS 173273]) and PRD-022. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-002/T-012, and PRD-002/T-022. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] Applicable sections of the DOE Handbook will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.9.1.2 General Radiation Dose Criteria for Occupational Personnel

Criteria—The repository surface and subsurface facility design shall meet the general dose criteria provided in Table 4.9.1-1 for occupational personnel. The dose criteria for the general public are addressed separately as part of the PSA.

Technical Rationale—The general radiation dose criteria are required to meet the occupational dose requirements in 10 CFR 20.1201 [DIRS 173165]. The YMP ALARA design goals are specified in Section 4.9.3.

Table 4.9.1-1. General Occupational Dose Criteria

Description	Criteria	Basis
Maximum individual total effective dose equivalent (TEDE)	5 rem/yr	Compliance with 10 CFR 20.1201 (a)(1)(i) [DIRS 173165]
Maximum sum of deep-dose equivalent and committed dose equivalent to any organ or tissue other than the lens of the eye	50 rem/yr	Compliance with 10 CFR 20.1201 (a)(1)(ii) [DIRS 173165]
Maximum lens dose equivalent	15 rem/yr	Compliance with 10 CFR 20.1201 (a)(2)(i) [DIRS 173165]
Maximum shallow-dose equivalent to the skin or any extremity	50 rem/yr	Compliance with 10 CFR 20.1201 (a)(2)(ii) [DIRS 173165]

4.9.1.3 Specific Dose Rate Criteria for Shielding Design

Criteria—The specific dose rate criteria for use in shielding design for the surface and subsurface facilities (Table 4.9.1-2) shall be consistent with the general dose criteria established in Table 4.9.1-1 and the ALARA design goals specified in Section 4.9.3.

Table 4.9.1-2. Specific Dose Rate Criteria for Shielding Design

Description Surface Facilities	Criteria[a]	Basis
Dose rates exterior to SNF/HLW process facilities at personnel level[b]	≤ 0.25 mrem/hr	To allow continuous occupational access in support of ALARA goal of 500 mrem/yr.
Dose rates exterior to SNF/HLW process facilities above the personnel level[b]	≤ 2.5 mrem/hr	Higher dose rate is allowed above personnel level provided the contribution from the high level will not cause the dose rate on the personnel level to exceed the criterion. Does not include areas that affect external stairways.
Operating galleries, support rooms, offices on personnel level[b]	≤ 0.25 mrem/hr	To allow continuous occupational access in support of ALARA goal of 500 mrem/yr.
Operating galleries, support rooms, offices above personnel level[b]	≤ 2.5 mrem/hr	Higher dose rate is allowed above personnel level provided the contribution from the high level will not cause the dose rate on the personnel level to exceed the criterion.
Intermittent access in restricted areas	≤ 100 mrem/hr	Dose rate criterion will vary with the access requirement for each area provided the general dose criteria are met.
Outside or beyond the restricted area boundary	≤ 0.05 mrem/hr	Applicable to controlled and unrestricted areas where members of the public have access to comply with 10 CFR 20.1301(a)(2) [DIRS 173165]. Includes normal operations and Category 1 event sequences.
Waste package transporter at 30 cm[c] from external accessible surface	≤ 100 mrem/hr	Minimal access is required around the waste package transporter during normal operations. Shielding is to protect operators when working around the transporter. These activities include, but are not limited to, locomotive operation, transport survey, and decontamination activities.

Table 4.9.1-2. Specific Dose Rate Criteria for Shielding Design (Continued)

Description Surface Facilities	Criteria[a]	Basis
Access main	≤ 5 mrem/hr	For the area facing each emplacement drift. The dose rate for the area between the two adjacent drifts is considerably lower because of substantial shielding by the host rock for conditions without the waste package transporter present in the access main.
Turnout ventilation door location	≤ 20 mrem/hr	For the dose rates on the access main side of the door. Access is only expected for door maintenance.
Exhaust main	N/A	Normal access is precluded, because of thermal conditions in the exhaust main.

NOTES: [a] The dose rate criteria are set on the basis of deep dose equivalent for static whole body radiation fields. Higher dose rates may be accepted for transient radiation fields (e.g., source movements). Higher dose rates may also be accepted for localized radiation fields (e.g., beams) that are not likely to result in significant whole body dose. Dose rate criterion exceptions are subject to an appropriate ALARA justification that may include the effect on individual annual doses.

[b] Personnel level is defined as the level within 8-ft height.

[c] The distance criterion is per definition of high radiation area in 10 CFR 20.1003 [DIRS 173165].

Technical Rationale—The specific dose rate criteria are required for the surface and subsurface facility shielding design to determine shielding thickness. These criteria are consistent with the general dose criteria provided in Section 4.9.1.2 and based on the personnel access requirements and radiological classifications for the various facility areas.

4.9.1.4 Shielding Source Term Criteria

Criteria—Shielding source terms for the surface and subsurface facility design shall be based on the limiting waste form as well as the limiting waste package type.

Design basis and maximum source terms shall be established to provide sufficient and bounding coverage, respectively, of the historical and projected fuel inventory for normal operations and Category 1 event sequences. The design basis source term shall cover a minimum of 95 percent of the total inventory, with provisions made available to accommodate the remaining 5 percent. The maximum source term shall represent the bounding fuel assembly in the entire inventory to be received at the repository. Use of the design basis or maximum source term shall be justified on a case-by-case basis.

Minimum initial enrichment shall be established in accordance with "Interim Staff Guidance - 6. Establishing Minimum Initial Enrichment for the Bounding Design Basis Fuel Assembly(s)" (NRC 2001 [DIRS 160595]) for the selected fuel assembly used in determining the source term because lower enriched fuel irradiated to the same burnup as higher enriched fuel produces a higher source term.

Technical Rationale—The source term criteria are required to provide the radiation source terms as a basis for the surface and subsurface facility shielding design. These criteria are consistent with those used in the previous YMP shielding calculations and NRC regulatory guidance. "Contract No. DE-AC28-01RW12101 - Licensing Position-009, Waste Stream Parameters" (Williams 2003 [DIRS 166132]) provides guidance and design requirements for the waste stream parameters.

4.9.1.5 Flux-to-Dose-Rate Conversion Factors

Criteria—Shielding calculations shall use the flux-to-dose-rate conversion factors as provided in ANSI/ANS-6.1.1-1977, *Neutron and Gamma-Ray Flux-to-Dose-Rate Factors* [DIRS 107016], for converting the calculated neutron and gamma fluxes to the respective dose rates. The selection of this standard complies with 10 CFR 20.1004 [DIRS 173165], Table 1004 (b) 2, and is consistent with the specifications in NUREG-1567 (NRC 2000 [DIRS 149756], p. 7-12) and NUREG-1617 (NRC 2000 [DIRS 154000], p. 5-5).

Technical Rationale—The flux-to-dose-rate conversion factors are required to convert the calculated neutron and gamma fluxes to dose rates for demonstration of regulatory compliance. The NRC has accepted the use of the ANSI/ANS-6.1.1-1977 [DIRS 107016] standard for this conversion.

4.9.1.6 Shielding Computational Methods

Criteria—Shielding calculations shall be performed using the NRC-accepted computer codes that have been benchmarked, validated, qualified and baselined in accordance with the project software management procedure. The analytical tools may include codes that use Monte Carlo, deterministic transport, and point-kernel integration techniques for the various shielding problems encountered in the repository design.

Currently, these codes include MCNP, SCALE, QAD-CGGP, and PATH. Except for PATH, the NRC recognizes the acceptance of these codes for analysis for spent fuel storage facilities in NUREG-1567 (NRC 2000 [DIRS 149756], pp. 7-12 and 7-13). PATH is similar to the QAD-CGGP code, and accepted by the NRC in the GA-4 transportation cask certification.

Technical Rationale—The qualified shielding codes are required to perform shielding calculations. The NRC has accepted these computer codes for shielding analyses for spent fuel storage facilities and transportation packaging.

4.9.2 Criticality Design Criteria

4.9.2.1 Criticality Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Nuclear Engineering	Criticality[b]	ANSI/ANS-8.1-1983, ANSI/ANS-8.1-1998, ANSI/ANS-8.17-1984, ANSI/ANS-8.21-1995, ANSI/ANS-8.22-1997, ANSI/ANS-8.3-1997, ASTM C992-89 (Reapproved 1997)
		NUREG-1520, NUREG-1567, Regulatory Guide 3.71
		10 CFR 63.111(a), 10 CFR 63.111(b), 10 CFR 63.112 (e)(6), 10 CFR 63.113, 10 CFR Part 72
		None

Technical Rationale:

[1] These codes and standards support compliance with the requirements of *the PRD* (Canori and Leitner 2003 [DIRS 166275]) such as PRD-022 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21 (c)(2) [DIRS 173273]). Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This regulatory guide and NUREG have been determined to be useful to the development of design products for the committed design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide.

[3] The CFRs are the basis for the requirements in PRD-002/T-012, and PRD-014/T-023. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.9.2.2 Criticality Safety Design Criteria

4.9.2.2.1

Criteria—Repository facilities and packages shall be designed for nuclear criticality safety during preclosure. The criteria for nuclear criticality safety shall be met by the following:

- Under all normal conditions and Category 1 and Category 2 event sequences, the calculated multiplication factor, k_{eff}, at the upper limit of a two-sided 95 percent confidence interval, shall not exceed the upper subcritical limit (a limiting value of k_{eff} that accounts for biases and uncertainties, and an administrative margin to ensure subcriticality).

Technical Rationale—This criterion is a consequence of 10 CFR 63.112(e)(6) [DIRS 173273], which requires that the repository provide the means to prevent and control criticality.

4.9.2.2.2

Criteria—The engineered barrier system shall be redesigned if the total probability of criticality is greater than or equal to one over the 10,000 year regulatory period.

Technical Rationale—This is required by *Disposal Criticality Analysis Methodology Topical Report* (YMP 2003 [DIRS 165505], Section 3.2.3).

4.9.2.2.3

Criteria—To use moderator control for nuclear criticality safety during preclosure for a facility or package, the facility or package shall:

1. Limit the amount of moderator that may be present in any area where radioactive waste is being handled (cask unloading, storage areas, waste package loading area, and waste package closure area) to show that there is no criticality concern under all normal conditions, Category 1 event sequences, and Category 2 event sequences.

2. Have engineered barriers (e.g., seals, walls, barriers, curbs, and drains) to prevent moderator from other areas entering the area where radioactive waste is being handled, considering the potential hazards (e.g., seismic activity and fire fighting activities in adjacent areas) that could compromise the integrity of the engineered barriers.

3 Minimize the number of penetrations into moderator control areas, and provide limits and controls as necessary to maintain the moderator control.

4. Design any instrumentation and controls, which are used to detect or prevent the presence of moderator, to fail safe and function under normal conditions and Category 1 and Category 2 event sequences.

5. Limit the use of oils or other lubricants that may be present in any moderator control areas to those that have no more moderating effect than water.

6. Not preclude the addition of moderator-displacing filler material to waste packages loaded with bare SNF assemblies.

Technical Rationale—This criterion is based on ANSI/ANS-8.22-1997 [DIRS 158946], Section 5; NUREG-1520 (NRC 2002 [DIRS 159567], Section 5.4.3.4.2); and the PRD (Canori and Leitner 2003 [DIRS 166275], PRD-014/T-023).

4.9.2.2.4

Criteria—For fixed-neutron absorbers used for criticality control such as grid plates or inserts, no more than 75 percent credit of the neutron absorber content shall be used for preclosure criticality analyses, unless comprehensive fabrication acceptance tests verify that the presence and uniformity of the neutron absorber are more effective.

Technical Rationale—This criterion is based on NUREG-1567 (NRC 2000 [DIRS 149756], Section 8.4.1.1).

4.9.2.2.5

Criteria—For CSNF waste packages that use neutron absorber materials for criticality control, SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure that neutron absorber materials are inserted into the CSNF waste package, as required, to meet the probability levels used in the criticality FEPs screening evaluation.

Technical Rationale—This criterion is based on NUREG-1520 (NRC 2002 [DIRS 159567], Section 5.4.3.4.2) and ANSI/ANS-8.21-1995 [DIRS 144743], Section 5.

4.9.2.2.6

Criteria—SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure correct loading of the CSNF assemblies into a waste package as prescribed by the derived waste package loading curves, to meet the probability levels used in the criticality FEPs screening evaluation.

Technical Rationale—This criterion is based on NUREG-1520 (NRC 2002 [DIRS 159567], Section 5.4.3.4.2).

4.9.2.2.7

Criteria—SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure closure of the waste package is performed in a manner to preclude moderator intrusion unless the proposed quantity of moderator material can be shown to impose no criticality concerns through providing moderation (preclosure) or enhanced corrosion (postclosure)..

Technical Rationale—This criterion is based on NUREG-1520 (NRC 2002 [DIRS 159567], Section 5.4.3.4.2).

4.9.2.2.8

Criteria—SSCs shall be designed such that adequate controls and procedures can be effectively implemented to prevent and control criticality during processing, handling, transfer, or transport of the waste form or waste package in the preclosure period and to ensure compliance with the waste form and waste package performance objectives during the postclosure period.

Technical Rationale—This criterion is supported by the requirements in 10 CFR 63.112(e)(6) [DIRS 173273] for the preclosure period, and 10 CFR 63.113 [DIRS 173273] for the postclosure period.

4.9.2.2.9

Criteria—SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure that acceptable verification of the burnup assignment of received CSNF has been made, to meet the probability levels used in the criticality FEPs screening evaluation.

Technical Rationale—This criterion is required by *Disposal Criticality Analysis Methodology Topical Report* (YMP 2003 [DIRS 165505], Section 3.5.2.1.3).

4.9.3 As Low As is Reasonably Achievable Design Criteria

4.9.3.1 As Low As is Reasonably Achievable Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Nuclear Engineering	ALARA[b]	None
		NUREG-1567 (NRC 2000 [DIRS 149756]), NUREG-0800 (NRC 1987 [DIRS 103124]), Regulatory Guide 8.8, Regulatory Guide 8.10, Regulatory Guide 8.19, Regulatory Guide 8.34
		10 CFR 20.1003, 10 CFR 20.1101(b)(d), 10 CFR 63.111(a), 10 CFR 63.204
		DOE O 420.1A, DOE-HDBK-1169-2003

Technical Rationale:

[1] This code and standard supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022. Applicable sections of this code and standard will be determined during the design process and in the development of design products.

[2] This NUREG has been determined to be useful to the development of design products for the preliminary design. These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-002/T-012, and PRD-002/T-022. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] Addressing these DOE directives supports compliance with the requirements of PRD-018/P-019. Applicable sections of these DOE directives will be determined during the design process and in the development of design products.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.9.3.2 As Low As is Reasonably Achievable Design Criteria

Criteria—ALARA shall be a regulatory requirement for the Yucca Mountain repository.

Technical Rationale—10 CFR 63.111(a) [DIRS 173273] states that "the geologic repository operations area must meet the requirements of part 20 of this Chapter 10." A portion of part 20, 10 CFR 20.1101(b) [DIRS 173165], states "The licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)." In addition, 10 CFR Part 63 [DIRS 173273] and 10 CFR Part 20 [DIRS 173165] provide limits and constraints on radiation doses to the public.

4.9.3.3 As Low As is Reasonably Achievable Design Goals

The repository will receive, prepare, and package SNF and HLW for emplacement underground. This SNF and HLW contains large amounts of radioactive material, and this potential hazard must be handled in a manner that achieves radiation safety for the general public and repository workers. A combination of management commitments, radiation safety considerations for design development, and regulatory requirements and guidance is employed to achieve designs that support radiation safety at the Yucca Mountain repository. This discussion addresses incorporating the radiation safety philosophy ALARA principle in the design of repository facilities.

Criteria—The ALARA design goals for occupational workers are to ensure that individual and collective doses shall be maintained at ALARA levels during normal operations and as a result of Category 1 event sequences. Category 1 event sequences shall be included in worker dose assessments. The design process shall meet the following ALARA design goals:

- The ALARA design goal for individual radiation worker doses is to minimize the number of individuals that have the potential of receiving more than 500 mrem/yr TEDE. That goal is 10 percent of the annual TEDE limit in 10 CFR 20.1201 [DIRS 173165], and includes internal and external exposures.

- The ALARA design process is to ensure that the collective dose is maintained ALARA.

- The ALARA goal for onsite members of the public is to maintain individual doses ALARA below the annual TEDE limit of 100 mrem in 10 CFR 20.1301 [DIRS 173165].

- The annual TEDE to any real member of the public in the general environment will be limited to the preclosure standard in 10 CFR 63.204 [DIRS 173273], as well as the annual effluent dose limit of 10 mrem in 10 CFR 20.1101(d) [DIRS 173165].

Technical Rationale—The individual dose goal criterion is required to meet the regulatory guidance contained in Regulatory Guide 8.8 [DIRS 103312], which is a method acceptable to the NRC for implementing the regulatory requirements in 10 CFR 20.1101(b) [DIRS 173165]. This criterion supports compliance with 10 CFR 63.111 (b)(1) [DIRS 173273], which requires, in part, meeting the 10 CFR Part 20 [DIRS 173165] requirement to achieve occupational doses and doses to members of the public that are ALARA.

4.9.3.4 Cost Benefit Analysis—Value of Person—Rem Averted

Criteria—During development of a mature design or when designing modifications to operating facilities, qualitative cost benefit considerations shall be used for comparing design alternatives and justifying design decisions, where appropriate. In determining whether a dose-reducing design alternative is reasonable, $10,000 per person-rem averted shall guide decisions based on current industry practices. Other values may be used, as appropriate, with adequate justification and documentation.

Technical Rationale—This criterion is in accordance with the guidance provided in Regulatory Guide 8.8 [DIRS 103312] and related NUREGs. This guidance is a method acceptable to the NRC for implementing the regulatory requirements in 10 CFR 20.1101(b) [DIRS 173165]. 10 CFR Part 20 is applicable as required by 10 CFR 63.111(b)(1) [DIRS 173273]. The dollar person-rem value is required in order to perform cost benefit considerations.

4.9.3.5 Radiological Condition Area Classifications

Criteria—Radiological conditions in facility areas during normal operations and as a result of Category 1 event sequences are fundamental inputs for the ALARA design process. The classification of facility areas shall provide information to designers and engineers for minimizing occupational and public radiation doses by incorporating design features such as access control, equipment layout, and shielding design. Each area of the facility shall be classified by radiological conditions, including dose rate range and contamination information. This classification information is available to designers and engineers in developing and evaluating designs and alternatives. Areas shall be reevaluated as the expected radiological conditions change or as the facility design or functions change during the design evolution.

In the classification process, the dose rate ranges do not include dose rates due to background radiation. The classification of dose rates for a given area or room is normally based on the highest anticipated dose rates. Consideration may be made for localized elevated dose rates or transient elevated dose rates when determining the appropriate dose rate category for the area or room.

Onsite facility areas are classified by radioactive material contamination levels (surface and airborne) to support the ALARA design process. The classification of an area in terms of contamination will be more dependent on the type of control regime necessary than the mean or maximum contamination level present. This reflects the fact that the potential contamination is as important as the actual contamination. The contamination considered is due to licensed material, and does not include exposure due to naturally occurring radioactive material.

Technical Rationale—This criterion is required to mitigate potential risk associated with radiation dose to occupational workers and the public, and as an element of engineering controls applied to the GROA to support the ALARA philosophy. This criterion is based on the requirements of 10 CFR Part 20 [DIRS 173165] and the guidance of Regulatory Guide 8.8 [DIRS 103312] and NUREG-0800 (12.3) (NRC 1987 [DIRS 103124]).

4.9.3.6 Worker Dose Assessment

Criteria—Worker dose assessments for demonstration of regulatory compliance shall include annual doses for both normal operations and Category 1 event sequences in compliance with 10 CFR 63.111(b)(1) [DIRS 173273]. Annual TEDEs, including internal and external exposures, shall be calculated by summing the contributions from normal operations and frequency-weighted doses from Category 1 event sequences.

Technical Rationale—The worker dose assessment criterion is required to calculate annual individual and collective doses to workers, including normal operations and Category 1 event sequences. The summation approach is consistent with that used for offsite dose consequence calculations as part of the preclosure analysis and has been accepted by the NRC for demonstration of compliance with 10 CFR 63.111(b)(1) [DIRS 173273].

4.9.4 Control of Access to High Radiation Areas

4.9.4.1 Control of Access to High Radiation Areas with Dose Rates Greater Than 100 mrem/hr to 1.0 rem/hr at 30 cm from the Radiation Source or from Any Surface Penetrated by the Radiation

Criteria—As provided in 10 CFR 20.1601(c) [DIRS 173165], the following controls, as described in Regulatory Guide 8.38, *Control of Access to High and Very High Radiation Areas in Nuclear Power Plants* [DIRS 106181], C.2, shall be applied to high radiation areas in place of the controls required by 10 CFR 20.1601(a) and 10 CFR 20.1601(b) [DIRS 173165]:

1. High radiation areas with dose rates not exceeding 1.0 rem/hr at 30 centimeters from the radiation source or from any surface penetrated by the radiation:

   a. Each entryway to such an area shall be barricaded[1] and conspicuously posted as a high radiation area. Such barricades may be opened, as necessary, to permit entry or exit of personnel or equipment.

   b. Access to, and activities in, each such area shall be controlled by means of a radiation work permit (RWP) or equivalent that includes the specification of radiation dose rates in the immediate work area(s) and other appropriate radiation protection equipment and measures.

   c. Individuals qualified in radiation protection procedures and personnel continuously escorted by such individuals may be exempted from the requirement for an RWP or equivalent while performing their assigned duties provided that they are otherwise following plant radiation protection procedures for entry to, exit from, and work in such areas.

   d. Each individual or group entering such an area shall possess:

      1) A radiation monitoring device that continuously displays radiation dose rates in the area, or

      2) A radiation monitoring device that continuously integrates the radiation dose rates in the area and alarms when the dose alarm setpoint for the device is reached, with an appropriate alarm setpoint, or

[1] A barricade can be a rope, ribbon, or other firmly secured, conspicuous obstacle that (by itself or used with physical barriers such as existing walls or hand railings) completely surrounds the area and obstructs inadvertent access.

3) A radiation monitoring device that continuously transmits dose rate and cumulative dose information to a remote receiver monitored by radiation protection personnel responsible for controlling personnel radiation exposure within the area, or

4) A self-reading dosimeter (e.g., pocket ionization chamber or electronic dosimeter) and,

   a) Be under the surveillance, as specified in the RWP or equivalent and while in the area, of an individual qualified in radiation protection procedures who is equipped with a radiation monitoring device that continuously displays radiation dose rates in the area and responsible for controlling personnel exposure within the area, or

   b) Be under the surveillance, as specified in the RWP or equivalent and while in the area, by means of CCTV, of personnel qualified in radiation protection procedures who are responsible for controlling personnel radiation exposure in the area and have the means to communicate with individuals in the area who are covered by such surveillance.

e. Except for individuals qualified in radiation protection procedures or personnel continuously escorted by such individuals, entry into such areas shall be made only after dose rates in the area have been determined and entry personnel are knowledgeable of them. These continuously escorted personnel will receive a prejob briefing prior to entry into such areas. This dose rate determination, knowledge, and pre-job briefing does not require documentation prior to initial entry.

Technical Rationale—This is to ensure that the regulatory mandated access controls to high radiation areas are incorporated into applicable facilities.

4.9.4.2 Control Access to High Radiation Areas with Dose Rates Greater Than 1.0 rem/hr at 30 cm From Radiation Source or From Any Surface Penetrated By Radiation But Less Than 500 rads/hr at 1 m From Radiation Source or From Any Surface Penetrated By Radiation

Criteria

1. Each entryway to such an area shall be conspicuously posted as a high radiation area and provided with a locked or continuously guarded door or gate that prevents unauthorized entry and, in addition:

   a. All such door and gate keys shall be maintained under the administrative control of the shift supervisor, radiation protection manager, or his or her designees, and

   b. Doors and gates shall remain locked except during periods of personnel or equipment entry or exit.

2. Access to, and activities in, each such area shall be controlled by means of an RWP or equivalent that includes the specification of radiation dose rates in the immediate work area(s) and other appropriate radiation protection equipment and measures.

3. Individuals qualified in radiation protection procedures may be exempted from the requirement for an RWP or equivalent while performing radiation surveys in such areas provided that they are otherwise following plant radiation protection procedures for entry to, exit from, and work in such areas.

4. Each individual or group entering such an area shall possess:

    a. A radiation monitoring device that continuously integrates the radiation dose rates in the area and alarms when the dose alarm setpoint for the device is reached, with an appropriate alarm setpoint, or

    b. A radiation monitoring device that continuously transmits dose rate and cumulative dose information to a remote receiver monitored by radiation protection personnel responsible for controlling personnel radiation exposure within the area and with the means to communicate with and control every individual in the area, or

    c. A self-reading dosimeter (e.g., pocket ionization chamber or electronic dosimeter) and,

        1) Be under the surveillance, as specified in the RWP or equivalent and while in the area, of an individual qualified in radiation protection procedures who is equipped with a radiation monitoring device that continuously displays radiation dose rates in the area and responsible for controlling personnel exposure within the area, or

        2) Be under the surveillance, as specified in the RWP or equivalent and while in the area, by means of CCTV, or personnel qualified in radiation protection procedures who are responsible for controlling personnel radiation exposure in the area and have the means to communicate with individuals in the area who are covered by such surveillance.

    d. In cases where options b) and c) above are impractical or determined to be inconsistent with the ALARA principle, a radiation monitoring device that continuously displays radiation dose rates in the area will be used.

5. Except for individuals qualified in radiation protection procedures or personnel continuously escorted by such individuals, entry into such areas shall be made only after dose rates in the area have been determined and entry personnel are knowledgeable of them. These continuously escorted personnel will receive a pre-job briefing prior to entry into such areas. This dose rate determination, knowledge, and pre-job briefing does not require documentation prior to initial entry.

6. Such individual areas that are within a larger area where no enclosure exists for the purpose of locking and no enclosure can reasonably be constructed around the individual area need not be controlled by a locked door or gate, nor continuously guarded, but shall be barricaded and conspicuously posted. A clearly visible flashing light shall be activated at the area as a warning device.

Technical Rationale—This is to ensure that the regulatory mandated access controls to high radiation areas are incorporated into applicable facilities.

4.9.4.3 Control of Access to Very High Radiation Areas

Criteria—The licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates (10 CFR 20.1602 [DIRS 173165]).

Technical Rationale—This is to ensure that the regulatory mandated access controls to very high radiation areas are incorporated into applicable facilities. Regulatory Guide 8.38 [DIRS 106181], C.3, provides the description for additional measures for controlling access to very high radiation areas.

4.10 OFFSITE INTERFACE DESIGN CRITERIA

4.10.1 Offsite Utility Interface Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Codes of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Offsite Utility Interface[b]	To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

[1] None.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.10.2 Transportation Project Interface Design Criteria

To be added later.

4.11 PLANT DESIGN CRITERIA

4.11.1 Surface Design Criteria

4.11.1.1 Surface Code and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Codes of Federal Regulations (CFRs)[3], DOE Directives[4].
Civil/ Structural/ Architectural	Architectural	ICC 2000 [DIRS 159179], NFPA 101®-2003
		Regulatory Guide 8.8
		28 CFR Part 36, 29 CFR Part 1910, 36 CFR Part 1191
		None

Technical Rationale:

[1] These codes and standards support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This regulatory guide has been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide. Addressing this regulatory guide supports compliance with requirements for surface design.

[3] Addressing CFRs supports compliance with requirements in PRD-015/P-015, PRD-002/T-012, and PRD-002/T-022. Applicable sections of these documents will be determined during the design process and in the development of design products.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.11.1.2 Building Configuration

The sizes, shapes, volumes, and arrangement of buildings, structures, and other surface site features shall comply with applicable codes and standards in accordance with the following.

4.11.1.2.1 Building Separation, Ground Surface Area and Height

Criteria—The distance between buildings, allowable areas, and heights shall comply with *International Building Code 2000* (ICC 2000 [DIRS 159179]). This code includes references to NFPA 101® [DIRS 165076].

Technical Rationale—This establishes a minimum separation for fire separation in industrial occupancies and a maximum allowable floor area and overall height.

4.11.1.2.2 Site Circulation and Accessibility

Criteria—The access and egress drives and site circulation to and from buildings shall comply with *International Building Code 2000* (ICC 2000 [DIRS 159179]), Americans with Disabilities Act [DIRS 162264], 28 CFR Part 36, Judicial Administration: Nondiscrimination on the Basis of Disability by Public Accommodations and in Commercial Facilities [DIRS 173317], 36 CFR Part 1191, Parks, Forests, and Public Property: Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities [DIRS 116969], and *Occupational Safety and Health Standards* (29 CFR Part 1910 [DIRS 172709]).

Technical Rationale—This ensures that personnel and vehicles have safe and accessible operating areas in and around buildings and structures.

4.11.2 Subsurface Design Criteria

4.11.2.1 Subsurface Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Mining	Subsurface[b]	None
		Regulatory Guide 8.8
		10 CFR 63.111(b), 10 CFR 63.111(d), 10 CFR 63.112(e), 10 CFR 63.132(a)
		None

Technical Rationale:

[1] None.

[2] This regulatory guide has been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide. Addressing this regulatory guide supports compliance with requirements for subsurface design.

[3] Addressing CFRs supports compliance with the requirements in PRD-015/P-020, PRD-015/P-021, PRD-002/T-012, and PRD-022/P-001. Applicable sections of these documents will be determined during the design process and in the development of design products. Addressing these regulations will demonstrate compliance with requirements for the Subsurface Facility. The DOE is not subject to the MSHA (30 CFR Part 57 [DIRS 173370]) as to the construction and operation of any facilities in the GROA.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.11.2.2 Not Used

4.11.2.2.1 Not Used

4.11.2.2.2 Not Used

4.11.2.2.3 Not Used

4.11.2.2.4 Not Used

4.11.2.2.5 Not Used

4.11.2.2.6 Not Used

4.11.2.3 Opening Stability

4.11.2.3.1

Criteria—The emplacement drifts shall be oriented at least 30 degrees from the dominant joint set per *TBV-361 Resolution Analysis: Emplacement Drift Orientation* (CRWMS M&O 1999 [DIRS 115042], p. 26).

Technical Rationale—This is to provide for stable emplacement drift openings.

NOTE: The emplacement drifts are presently located along an azimuth of 252 degrees or alternately an azimuth of 72 degrees (180 degrees from 252 degrees) (BSC 2003 [DIRS 165572], Section 5.1.4).

4.11.2.3.2

Criteria—The vertical separation between crossing drifts shall be a minimum of 10 m (33 ft) from the crown of the lower opening to the invert of the upper opening (BSC 2004 [DIRS 168178], p. 208).

Technical Rationale—This is to ensure stable openings when drifts cross at different elevations.

4.11.2.3.3

Criteria—The minimum spacing (centerline-to-centerline) for nonemplacement drifts, running parallel, shall be three diameters, based upon the diameter of the larger drift (Obert and Duvall 1967 [DIRS 173469], Figure 16.2.2, p. 497).

Technical Rationale—This is to provide for stable openings.

4.11.2.3.4

Criteria—The access mains and ramps shall be a nominal 7.62 m (25 ft) in diameter (BSC 2003 [DIRS 165572], Tables 4, 5, and 6).

Technical Rationale—This criterion establishes a nominal opening for use in designing mobile equipment that is intended to use these openings. This diameter is the same as the excavated diameter of the existing Exploratory Studies Facility.

4.11.2.4 Emplacement Drift Configuration

4.11.2.4.1

Criteria—The excavated diameter of openings that are used to dispose of waste packages shall be a nominal of 5.5 m (18 ft) (BSC 2003 [DIRS 165572], Tables 3, 4, 5, and 6).

Technical Rationale—This establishes a nominal opening for use in designing emplacement drift fittings and the mobile equipment that is intended to use the emplacement drifts.

4.11.2.4.2

Criteria—The emplacement drift spacing (center-to-center) shall be a nominal 81 m (266 ft) (BSC 2003 [DIRS 165572], Table III-1).

Technical Rationale—This assumed drift spacing promotes drainage of thermally mobilized water and keeps individual drifts from thermal interaction with adjacent drifts.

4.11.2.4.3

Criteria—The grade of the emplacement drifts shall be horizontal (BSC 2003 [DIRS 165572], Section 7.2.6).

Technical Rationale—This is to ensure that any water entering the emplacement drift will not collect in pools. It is desired that the water drain uniformly along the length of the drift.

4.11.2.5 Miscellaneous

4.11.2.5.1

Criteria—Portal and shaft/raise collar openings shall be protected from the probable maximum flood. (BSC 2003 [DIRS 165572], Section 7.2.3).

Technical Rationale—This will prevent surface waters from entering the emplacement drifts and shaft openings during times of flooding.

4.11.2.5.2

Criteria—The surface gradient at the portal openings and shaft collars shall be down gradient and away from the openings (BSC 2003 [DIRS 165572], Section 7.2.4).

Technical Rationale—This will preclude surface runoff from rain or spills from entering the openings.

4.11.3 Piping Design Criteria

4.11.3.1 Piping Design Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Plant Design	Piping[b]	ASME B31.3-2002
		Regulatory Guide 8.8
		None
		None

Technical Rationale:

[1] This code supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]), such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]) and PRD-022. Applicable sections of these codes and standards will be determined during the design process and in the development of design products.

[2] This regulatory guide has been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide. Addressing this regulatory guide supports compliance with requirements for piping design.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.12 SOLAR POWER STATION DESIGN CRITERIA

4.12.1 Solar Power Station Design Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Electrical	Solar Power Station[b]	To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

[1] None.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

4.12.2 Solar Power Station Design Criteria

NOTE: The solar power system is currently under review and may be eliminated upon further evaluation.

4.12.2.1

Criteria—Solar power systems shall be provided in conjunction with normal utility power systems.

Technical Rationale—This criterion is required to facilitate renewable energy sources to supplement commercial power. The solar electrical power panels will be built in a phased fashion at the site with a capacity of up to 3 MW (Canori and Leitner 2003 [DIRS 166275], PRD-014/T-025).

4.12.2.2

Criteria—Applicable industry solar power standards shall apply to the site solar power system.

Technical Rationale—This criterion is required because the solar power development is still in the infancy stage. The quality of system and equipment shall be as close to state of art as possible.

5. WASTE PACKAGE AND COMPONENTS DESIGN CRITERIA

5.1 WASTE PACKAGE MECHANICAL DESIGN CRITERIA

5.1.1 Structural Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Thermal/ Structural Analysis	Waste Package—Structural[b]	ANSI N14.6-1993, ASME 2001 (Section III, Division I, Subsection NC)
		None
		None
		None

Technical Rationale:

[1] These codes support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, the DOE and commercial waste package system, and naval SNF waste package system. Although ANSI N14.6-1993 [DIRS 102016] has been withdrawn pending revision, it will continue to be used as guidance for demonstrating the performance of the trunnion collar until the release of the revision.

ASME 2001 [DIRS 158115], Section III, Division 1, Subsection NC, provides rules for the design and fabrication of Class 2 nuclear components.

Design and fabrication of waste packages are to be performed to ASME 2001 [DIRS 158115], Section III, Division 1, Subsection NC (including 2002 Addenda) or, as negotiated, the ASME Code version in effect at the time of procurement.

ANSI N14.6-1993 [DIRS 102016] has been withdrawn pending revision; however, it will be used as guidance until the release of the revision.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTES:

[1] The application of the ASME Boiler and Pressure Vessel Code to the design of the waste package is described in a position paper (BSC 2004 [DIRS 172191]) that states in detail which sections of the code are applicable and how those sections are applied. Although ANSI N14.6-1993 [DIRS 102016] has been withdrawn pending revision, it will continue to be used as guidance for demonstrating the performance of the trunnion collar until the release of the revision.

[2] Except for waste packages containing self-moderating waste forms, if it can be demonstrated by analysis that the waste package does not breach and maintains the hermeticity of the volume in which the waste form is located, it is then not necessary to demonstrate the continued integrity of the waste form and the basket for the purpose of maintaining margin to criticality during the preclosure period.

[3] The event sequences applicable to the waste package and a description of these event sequences may be found in *Categorization of Event Sequences for License Application* (BSC 2005 [DIRS 174467]). Waste package loads are subsequently computed from the analysis of these defined event sequences.

5.1.2 Metallurgical Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Thermal/Structural Analysis	Waste Package—Metallurgical[b]	ASME 2001 (Section II), ASME 2001 (Section III, Division I, Subsection NC 2000)
		None
		None
		None

Technical Rationale:

[1] These codes support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]), such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, the DOE and commercial waste package system, and the naval SNF waste package system.

ASME 2001 [DIRS 158115], Section II and Section III, Division 1, Subsection NC 2000, provide the structural and thermal properties for materials used in the design and fabrication of nuclear components.

Design and fabrication of waste packages are to be performed to ASME 2001 [DIRS 158115], Section III, Division 1, Subsection NC or, as negotiated, the ASME Code version in effect at the time of procurement.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: ASME 2001 [DIRS 158115], Section II, does not contain an exhaustive list of material properties and it may be necessary to obtain values from other sources as appropriate. Possible additional sources of material properties are identified in *Waste Package Component Design Methodology Report* (Mecham 2004 [DIRS 170673], Sections 4.2.2 and 4.2.3).

5.1.3 Waste Package Thermal Design Criteria

5.1.3.1 Thermal Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Thermal/Structural Analysis	Waste Package—Thermal[b]	None
		None
		None
		None

Technical Rationale:

[1] No codes or standards have been identified at this time.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

5.1.3.2 Temperature Limits

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Thermal/Structural Analysis	Waste Package—Thermal[b]	None
		Interim Staff Guidance 11 (NRC 2003 [DIRS 170332])
		None
		DOE 2003 [DIRS 167367]

Technical Rationale:

[1] No codes or standards have been identified at this time.

[2] Interim Staff Guidance 11 (NRC 2003 [DIRS 170332]) requires that thermal cycling of a nuclear component with more than a 65°C temperature difference be limited to no more than 10 cycles.

[3] None.

[4] The maximum subsurface temperature limit has been specified by *Repository Design Asset Functional and Operational Requirements and Design Solutions* (DOE 2003 [DIRS 167367]). A maximum commercial SNF cladding temperature in an inerted environment criterion of 350°C following the sealing of the waste package ensures that the maximum subsurface temperature limit will be met (see Section 6.3 for commercial SNF cladding temperature limits during surface facility operations).

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: Interim Staff Guidance 11 (NRC 2003 [DIRS 170332], Appendix A, p. 3) requires the waste package to maintain a commercial SNF zircaloy peak cladding temperature below 400°C during normal storage (inerted environment) and short term loading operations (in air) and below 570°C during an accident condition involving a fire (inerted environment).

5.2 WASTE PACKAGE FABRICATION CRITERIA

5.2.1 Fabrication Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Waste Package—Fabrication[b]	ANSI/AWS A2.4-98, ANSI/AWS A5.32/A5.32M-97, ANSI N14.6-1993, ASME 2001 (Section II), ASME 2001 (Section III, Subsection NCA), ASME 2001 (Section III, Division I, Subsections NB, NC, and NF), ASME 2001 (Section V), ASME 2001 (Section IX), ASME B46.1-2002, ASME NQA-1 2000 (Subparts 2.1 and 2.2), ASME Y14.36M-1996, ASME Y14.38-1999, ASME Y14.5M-1994
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, the DOE and commercial waste package system, and naval SNF waste package system.

ANSI/AWS A2.4-98 [DIRS 159557] provides the standard symbols for the welding, brazing, and nondestructive examination of nuclear components.

ANSI/AWS A5.32/A5.32M-97 [DIRS 160420] provides the specifications of welding shielding gases used in the welding processes of nuclear components.

ANSI N14.6-1993 [DIRS 102016] has been withdrawn pending revision; however, it will be used as guidance until the release of the revision.

ASME 2001 [DIRS 158115], Section II, provides the properties for the materials used in the design and fabrication of Class 2 nuclear components.

ASME 2001 [DIRS 158115], Section III, Subsection NCA, provides the rules and general requirements for the construction of Division 1 components, including the requirements for affixing a code stamp.

ASME 2001 [DIRS 158115], Section III, Division I, Subsection NB, provides rules for the design and fabrication of Class 1 nuclear components.

ASME 2001 [DIRS 158115], Section III, Division I, Subsection NC, provides rules for the design and fabrication of Class 2 nuclear components.

ASME 2001 [DIRS 158115], Section III, Division I, Subsection NF, provides the general requirements for the design and fabrication of supports for Class 2 nuclear components.

ASME 2001 [DIRS 158115], Section V, provides the requirements for the nondestructive examination of nuclear components.

ASME 2001 [DIRS 158115], Section IX, provides welding and brazing qualifications for the welding of nuclear components.

Design and fabrication of waste packages are to be performed to ASME 2001 [DIRS 158115], Section III, Division 1, Subsection NC (including 2002 Addenda) or, as negotiated, the ASME Code version in effect at the time of procurement.

ASME B46.1-2002 [DIRS 166013] provides surface texture (surface roughness, waviness, and lay) requirements for fabrication of nuclear components.

ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications* [DIRS 159544], Subparts 2.1 and 2.2, provides the quality assurance requirements for the cleaning, packaging, shipping, receiving, storage, and handling of items of nuclear facilities.

ASME Y14.36M-1996 [DIRS 159536] provides the requirements for surface texture symbols used in the designing of nuclear components.

ASME Y14.38-1999 [DIRS 159534] provides the requirements for abbreviations and acronyms used in the designing of nuclear components.

ASME Y14.5M-1994 [DIRS 159535] provides the requirements for dimensioning and tolerancing used in the designing of nuclear components.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTES:

[1] The QARD (DOE 2004 [DIRS 171539], Section 13.0) does not define specific technical requirements for cleaning, packaging, shipping, storage, and handling of items (including nuclear components). ASME NQA-1-2000 [DIRS 159544], Subparts 2.1 and 2.2, is imposed to augment the requirements of DOE 2004 [DIRS 171539].

[2] ASME 2001 [DIRS 158115], Section II, does not contain an exhaustive list of material properties, and it may be necessary to obtain values from other sources as appropriate. Possible additional sources of material properties are identified in *Waste Package Component Design Methodology Report* (Mecham 2004 [DIRS 170673], Sections 4.2.2 and 4.2.3).

5.3 WASTE PACKAGE CLOSURE SYSTEM DESIGN CRITERIA

5.3.1 Waste Package Closure System Equipment Design Criteria

5.3.1.1 Welding Equipment Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Welding Equipment[b]	ASME NQA-1-2000
		None
		None
		None

Technical Rationale:

[1] ASME NQA-1-2000 [DIRS 159544] supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c) (2) [DIRS 173273]), PRD-022, and the waste package closure system.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: There are no specific industry standards for the fabrication of welding equipment. ASME NQA-1-2000 [DIRS 159544] has been selected to provide a high degree of confidence in the fabrication of this equipment.

5.3.1.2 Nondestructive Examination Equipment Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Nondestructive Examination Equipment[b]	ASME NQA-1-2000
		None
		None
		None

Technical Rationale:

[1] ASME NQA-1-2000 [DIRS 159544] supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the waste package closure system.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: There are no specific industry standards for the fabrication of nondestructive examination equipment. ASME NQA-1-2000 [DIRS 159544] has been selected to provide a high degree of confidence in the fabrication of this equipment.

5.3.1.3 Inerting Equipment Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Inerting Equipment[b]	ASME NQA-1-2000
		To be added later
		To be added later
		To be added later

Technical Rationale:

[1] ASME NQA-1-2000 [DIRS 159544] supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the waste package closure system.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTES:

[1] There are no specific industry standards for the fabrication of inerting equipment. ASME NQA-1-2000 [DIRS 159544] has been selected to provide a high degree of confidence in the fabrication of this equipment.

[2] The requirements for designing the inert gas system can be found in CGA P-9, *The Inert Gases: Argon, Nitrogen, and Helium* [DIRS 166794].

5.3.1.4 Stress Mitigation Equipment Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Stress Mitigation Equipment[b]	ASME NQA-1-2000
		None
		None
		None

Technical Rationale:

[1] ASME NQA-1-2000 [DIRS 159544] supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the waste package closure system.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: There are no specific industry standards for the fabrication of stress mitigation equipment. ASME NQA-1-2000 [DIRS 159544] has been selected to provide a high degree of confidence in the fabrication of this equipment.

5.3.1.5 Remote Handling Equipment Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Remote Handling Equipment[b]	ASME B30.20-2003, ASME NQA-1-2000, CMAA-70-2000
		None
		None
		DOE-STD-1090-2001

Technical Rationale:

[1] These standards support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the waste package closure system.

ASME NQA-1-2000 [DIRS 159544] provides quality assurance requirements for the design of nuclear facility applications.

ASME B30.20-2003 [DIRS 171688] provides the lifting device requirements for the design of the waste package closure cell.

CMAA-70-2000 [DIRS 153997] provides the crane and gantry requirements for the design of the waste package closure cell.

[2] None.

[3] None.

[4] DOE-STD-1090-2001 [DIRS 169284] provides the crane and gantry requirements for the design of the waste package closure cell.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: ASME NQA-1-2000 [DIRS 159544] has been selected to provide a high degree of confidence in the fabrication of this equipment.

5.3.1.6 Control Equipment Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Controls Equipment[b]	ASME NQA-1-2000, NFPA 70-2004, IEEE Std 1202-1991, ANSI/IEEE Std 383™-2003
		None
		None
		None

Technical Rationale:

[1] These standards support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the waste package closure system.

ASME NQA-1-2000 [DIRS 159544] provides quality assurance requirements for the design of nuclear facility applications.

NFPA 70-2004 [DIRS 172711] provides the electrical requirements used in the design of the waste package closure cell.

IEEE Std 1202-1991 [DIRS 160800] provides electrical requirements used in the design of the waste package closure cell.

ANSI/IEEE Std 383™-2003 [DIRS 171695] provides electrical requirements used in the design of the waste package closure cell.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: ASME NQA-1-2000 [DIRS 159544] has been selected to provide a high degree of confidence in the fabrication of this equipment.

5.3.2 Waste Package Closure System Process Criteria

5.3.2.1 Welding Process Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Welding Process	ASME 2001 (Section II. SFA-5.9, 5.12, 5.14, and 5.32); ASME 2001 (Section IX)
		None
		None
		None

Technical Rationale:

[1] ASME 2001 [DIRS 158115] supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the waste package closure system.

ASME 2001 [DIRS 158115], Section II (SFA-5.9, 5.12, 5.14, and 5.32), will be used to define the material requirements for the weld filler metal with additional requirements being derived from project development studies.

ASME 2001 [DIRS 158115], Section IX, provides requirements for the qualification of welders, welding operators, and the procedures employed in welding operations.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

5.3.2.2 Nondestructive Examination Process Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Nondestructive Examination Process	ASME 2001 (Section III, Division I, Subsection NC), ASME 2001 (Section V)
		None
		None
		None

Technical Rationale:

[1] ASME 2001 [DIRS 158115] supports compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, and the waste package closure system.

ASME 2001 [DIRS 158115], Section III, Division 1, Subsection NC, will be used as a guide with modification as directed by the project.

ASME 2001 [DIRS 158115], Section V, nondestructive processes, performance qualifications, and acceptance requirements, will be used as a guide and modified as directed by the project.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

5.3.2.3 Inerting Process Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Inerting Process	None
		NUREG-1536 (NRC 1997 [DIRS 101903], 8.0.V.1)
		None
		None

Technical Rationale:

[1] None.

[2] NUREG-1536 (NRC 1997 [DIRS 101903]) will be used as a guide and modified as directed by the project.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

NOTE: The requirement for helium quality is found in ASME 2001 [DIRS 158115], Section II (SFA-5.32), Specification for Welding, Shielding Gases.

5.3.2.4 Stress Mitigation Process Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Stress Mitigation Process	None
		None
		None
		None

Technical Rationale:

1 No codes or standards have been identified at this time.

2 None.

3 None.

4 None.

a Safety classifications are only provided for SSCs.

5.4 EMPLACEMENT PALLET DESIGN CRITERIA

5.4.1 Structural Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Thermal/ Structural Analysis	Structural[b]	ASME 2001 (Section II), ASME 2001 (Section III, Division I, Subsection NC 2000)
		None
		None
		None

Technical Rationale:

[1] These codes support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]), such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]).

ASME 2001 [DIRS 158115], Section II and Section III, Division 1, Subsection NC 2000, provides the properties and general requirements, respectively, for materials used in the design and fabrication of nuclear components.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: ASME 2001 [DIRS 158115], Section II, does not contain an exhaustive list of material properties and it may be necessary to obtain values from other sources as appropriate. Possible additional sources of material properties are identified in *Waste Package Component Design Methodology Report* (Mecham 2004 [DIRS 170673], Sections 4.2.2 and 4.2.3).

5.5 EMPLACEMENT PALLET FABRICATION CRITERIA

5.5.1 Fabrication Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Pallet Fabrication[b]	ANSI/AWS A2.4-98, ANSI/AWS A5.32/A5.32M-97, ASME 2001 (Section II), ASME 2001 (Section III, Subsection NCA), ASME 2001 (Section III, Division I, Subsection NF), ASME 2001 (Section V), ASME 2001 (Section IX), ASME B46.1 2001, ASME NQA-1 2000 (Subparts 2.1 and 2.2), ASME Y14.38-1999, ASME Y14.5M-1994
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, the DOE and commercial waste package system, and naval SNF waste package system.

ANSI/AWS A2.4-98 [DIRS 159557] provides the standard symbols for the welding, brazing, and nondestructive examination of nuclear components.

ANSI/AWS A5.32/A5.32M-97 [DIRS 160420] provides the specifications of welding shielding gases used in the welding processes of nuclear components.

ASME 2001 [DIRS 158115], Section II, provides the properties for the materials used in the design and fabrication of Class NF nuclear components.

ASME 2001 [DIRS 158115], Section III, Subsection NCA, provides the rules and general requirements for the construction of Division 1 components, including the requirements for affixing a code stamp.

ASME 2001 [DIRS 158115], Section III, Division I, Subsection NF, provides the general requirements for the design and fabrication of supports for Class 2 nuclear components.

ASME 2001 [DIRS 158115], Section V, provides the requirements for the nondestructive examination of nuclear components.

ASME 2001 [DIRS 158115], Section IX, provides welding and brazing qualifications for the welding of nuclear components.

Fabrication of waste package pallets are to be performed to ASME 2001 [DIRS 158115], Section III, Division 1, Subsection NF (including 2002 Addenda) or, as negotiated, the ASME Code version in effect at the time of procurement.

ASME B46.1 [DIRS 166013] provides surface texture (surface roughness, waviness, and lay) requirements for fabrication of nuclear components.

ASME NQA-1-2000 [DIRS 159544], Subparts 2.1 and 2.2, provides the quality assurance requirements for the cleaning, packaging, shipping, receiving, storage, and handling of items of nuclear facilities.

ASME Y14.36M-1996 [DIRS 159536] provides the requirements for surface texture symbols used in the designing of nuclear components.

ASME Y14.38-1999 [DIRS 159534] provides the requirements for abbreviations and acronyms used in the designing of nuclear components.

ASME Y14.5M-1994 [DIRS 159535] provides the requirements for dimensioning and tolerancing used in the designing of nuclear components.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: The requirements of ASME NQA-1-2000 [DIRS 159544], Subparts 2.1 and 2.2, are imposed to define specific technical requirements for the cleaning, packaging, shipping, storage, and handling of items of nuclear components.

5.6 DRIP SHIELD DESIGN CRITERIA

5.6.1 Structural Design Criteria

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Thermal/ Structural Analysis	Structural[b]	None
		None
		None
		None

Technical Rationale:

[1] No codes or standards have been identified at this time.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

5.7 DRIP SHIELD FABRICATION CRITERIA

5.7.1 Fabrication Codes and Standards

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Waste Package Closure System	Drip Shield Fabrication[b]	ANSI/AWS A2.4-98, ANSI/AWS A5.32/A5.32M-97, ASME 2001 (Section II), ASME 2001 (Section III, Subdivision NCA), ASME 2001 (Section III, Division I, Subsection NF), ASME 2001 (Section V), ASME 2001 (Section IX), ASME B46.1 2002, ASME NQA-1 2000, Subparts 2.1 and 2.2, ASME Y14.36M-1996, ASME Y14.38-1999, ASME Y14.5M-1994
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with the requirements of the PRD (Canori and Leitner 2003 [DIRS 166275]) such as PRD-002/T-004 (information relative to codes and standards that the DOE proposes to apply to the design and construction of the GROA as required by 10 CFR 63.21(c)(2) [DIRS 173273]), PRD-022, the DOE and commercial waste package system, and naval SNF waste package system.

ANSI/AWS A2.4-98 [DIRS 159557] provides the standard symbols for the welding, brazing, and nondestructive examination of nuclear components.

ANSI/AWS A5.32/A5.32M-97 [DIRS 160420] provides the specifications of welding shielding gases used in the welding processes of nuclear components.

ASME 2001 [DIRS 158115], Section II, provides the properties for the materials used in the design and fabrication of Class NF nuclear components.

ASME 2001 [DIRS 158115], Section III, Subsection NCA, provides the rules and general requirements for the construction of Division 1 components, including the requirements for affixing a code stamp.

ASME 2001 [DIRS 158115], Section III, Division I, Subsection NF, provides the general requirements for the design and fabrication of supports for Class 2 nuclear components.

ASME 2001 [DIRS 158115], Section V, provides the requirements for the nondestructive examination of nuclear components.

ASME 2001 [DIRS 158115], Section IX, provides welding and brazing qualifications for the welding of nuclear components.

Fabrication of drip shields are to be performed to ASME 2001 [DIRS 158115], Section III, Division 1, Subsection NF (including 2002 Addenda) or, as negotiated, the ASME Code version in effect at the time of procurement.

ASME B46.1-2002 [DIRS 166013] provides surface texture (surface roughness, waviness, and lay) requirements for fabrication of nuclear components.

ASME NQA-1 2000 [DIRS 159544], Subparts 2.1 and 2.2, provides the quality assurance requirements for the cleaning, packaging, shipping, receiving, storage, and handling of items of nuclear facilities.

ASME Y14.36M-1996 [DIRS 159536] provides the requirements for surface texture symbols used in the designing of nuclear components.

ASME Y14.38-1999 [DIRS 159534] provides the requirements for abbreviations and acronyms used in the designing of nuclear components.

ASME Y14.5M-1994 [DIRS 159535] provides the requirements for dimensioning and tolerancing used in the designing of nuclear components.

[2] None.

[3] None.

[4] None.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

NOTE: The QARD (DOE 2004 [DIRS 171539], Section 13.0), does not define specific technical requirements for cleaning, packaging, shipping, storage, and handling of items of nuclear components. ASME NQA-1-2000 [DIRS 159544], Subparts 2.1 and 2.2, is imposed to augment the requirements of DOE 2004 [DIRS 171539].

5.8 INTERFACING CRITERIA

Applicable Discipline	Disciplines/ SSCs[a]	Applicable Codes/Standards/Industry Guides[1], Regulatory Guides/NUREGs[2], Code of Federal Regulations (CFRs)[3], DOE Directives[4]
Thermal/Structural Analysis	Interfacing[b]	None
		None
		None
		DOE 2002 [DIRS 158398]

Technical Rationale:

[1] No codes or standards have been identified at this time.

[2] None.

[3] None.

[4] Addressing this DOE directive supports compliance with requirements of PRD-014-/T-016. Applicable sections of this DOE directive will be determined during the design process in the development of design products. DOE 2002 [DIRS 158398], as directed by DOE, will be used to obtain the interface information of the DOE and naval waste forms necessary for the design of the DOE and naval waste package systems.

[a] Safety classifications are only provided for SSCs.

[b] Safety classifications can be found in *Q-List* (BSC 2005 [DIRS 174269]).

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6. SITE SPECIFIC CRITERIA

6.1 NATURAL PHENOMENA

6.1.1 Meteorological

6.1.1.1 Precipitation

6.1.1.1.1 Snowfall

Criteria—The system shall be designed to withstand and operate in the snowfall environments described in Table 6.1.1-1:

Table 6.1.1-1. Snowfall Environments

Parameter	Value
Maximum Daily Snowfall	6.0 in. (15.2 cm)
Maximum Monthly Snowfall	6.6 in. (16.8 cm)

Source: DTN: MO0504DSRKSNOW.001 [DIRS 173394].

Technical Rationale—Snowfall is one of the primary design parameters needed for exposed structures to ensure external loadings are accounted for. Snowfall and snow depth measurements were not part of the meteorological monitoring program at Yucca Mountain. Therefore, reasonable estimates of the Yucca Mountain snowfall environment are based upon climatological records from the Desert Rock Weather Service Meteorological Observatory (WSMO), Nevada, which is located approximately 45 km southeast of the repository site (DTN: MO0003YMP99042.001 [DIRS 148735]) at an elevation of 3,301 ft. The Desert Rock period of record is 01/01/1983 to 02/28/2005. These extremes are the actual observations recorded by the National Weather Service observers and are documented in DTN: MO0504DSRKSNOW.001 [DIRS 173394].

6.1.1.1.2 Rainfall

Criteria—The system shall be designed to withstand and operate in the precipitation environment described in Tables 6.1.1-2 and 6.1.1-3.

Table 6.1.1-2. Estimated Maximum Annual Precipitation

Parameter	Value
Maximum Annual Precipitation	20 in./yr (50.8 cm)

Table 6.1.1-3. Maximum 1-Hour and 24-Hour Precipitation Frequency Estimates

Parameter and Frequency	Nominal Estimate	Upper Bound 90% Confidence Interval
Maximum 24-hr Precipitation (50-year return period)	2.79 in./day (7.1 cm)	3.30 in./day (8.4 cm)
Maximum 24-hr Precipitation (100-year return period)	3.23 in./day (8.2 cm)	3.84 in./day (9.8 cm)
Maximum 24-hr Precipitation (500-year return period)	4.37 in./day (11.1 cm)	5.25 in./day (13.3 cm)
Precipitation 1-hr intensity (50-year return period)	1.35 in./hr (3.4 cm)	1.72 in./hr (4.4 cm)
Precipitation 1-hr intensity (100-year return period)	1.68 in./hr (4.3 cm)	2.15 in./hr (5.5 cm)

Source: National Oceanic and Atmospheric Administration Atlas 14 Website: http://hdsc.nws.noaa.gov/hdsc/pfds/, DTN: MO0403SEPPRFQE.000 [DIRS 169194].

NOTE: For conservative design, use values for upper bound "90% Confidence Interval."

The local storm probable maximum precipitation value at the North Portal pad is calculated to be 13.2 in. with a duration of 6 hours. The local 6-hour probable maximum precipitation at the South Portal is computed to be 12.9 in. (BSC 2004 [DIRS 169464], Section 4.2.2).

Technical Rationale—Precipitation is an environmental parameter that can affect site drainage and erosion, buried utilities, outdoor equipment seals, and roof drain system sizing. This criterion establishes the rainfall rates through which the affected systems must be able to endure and function. The maximum annual precipitation (Table 6.1.1-2) is conservatively based on the actual 12-month amount (18.97 in.) recorded at Yucca Mountain meteorological Site 6 (BSC 2003 [DIRS 163158], Addendum A) during water year 1997-1998 (DTN: MO0303SGPM9502.000 [DIRS 162490]). Because the period of record for Yucca Mountain site-specific precipitation data is limited to seven full years, a survey of nearby National Oceanic and Atmospheric Administration meteorological locations was conducted. These locations surround Yucca Mountain and provide a much longer record to further substantiate the conservative value in Table 6.1.1-2. The sites surveyed with the annual recorded extreme amount are Beatty 8N (12.62 in., 1972-2004); Amargosa Farms Garey (10.37 in., 1965–2004); Desert Rock WSMO (10.64 in., 1984–2004); and Nevada Test Site climate station, 4JA (14.40 in., 1957–2004). These annual extremes are documented in DTN: MO0409SEPNOAPD.000 [DIRS 171885]).

NOTE: The water year is defined as the 12-month period from October 1 through September 30 of the following year.

The 1-hour and 24-hour precipitation estimates were derived from the National Oceanic and Atmospheric Administration Atlas 14 and were specifically calculated for the Site 1 location (BSC 2003 [DIRS 163158], Addendum A) as shown in Table 6.1.1-3. For comparison, a survey of 1-hour precipitation records at Yucca Mountain from 1998 through 2002 (DTNS: MO0206SEPQ1998.001 [DIRS 166731], MO0302METMON99.001 [DIRS 166165], MO0209SEPQ2000.001 [DIRS 166730], MO0305SEP01MET.002 [DIRS 166164], and

MO0305SEP02MET.002 [DIRS 166163]) indicates that the maximum observed hourly precipitation event amounted to 1.24 in. (3.15 cm) at Site 7 (BSC 2003 [DIRS 163158], Addendum A), July 13, 1999, and the observed 24-hr precipitation event was 2.55 in. (6.48 cm) also at Site 7, July 13, 1999 (DTN: MO0302METMON99.001 [DIRS 166165]).

6.1.1.2 Winds

Criteria—The affected SSCs (the system components that are exposed to outside [ambient] wind conditions) shall be designed for a basic wind speed of 90 miles per hour. This value shall be used to design SC and non-SC SSCs. Further, the system shall operate during and after exposure to a surface basic wind speed of 90 miles per hour.

Technical Rationale—Wind is one of the primary external environmental parameters that can affect buildings and structures located outside. This criterion is needed to ensure the system equipment remains operational during and after exposure to expected environmental extremes. Proper consideration of wind is required to ensure that buildings and structures can withstand the wind forces, and that system components are adequately protected from the wind. Based on the requirements in NUREG-0800 (NRC 1987 [DIRS 103124], Sections 2.3.1 and 3.3.1), safety related buildings or structures must also be evaluated for the maximum wind speed. NUREG-0800 (NRC 1987 [DIRS 103124], Section 3.3.1.II.1) states: "The wind used in the design shall be the most severe wind that has been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data has been accumulated."

ASCE 7-98 [DIRS 149921], Figure 6-1, contains a map of basic wind speed values for the United States and identifies special wind regions to be examined for unusual wind conditions. The Yucca Mountain area is within one of the special regions. The default value outside the special region within which Yucca Mountain is located and for much of the continental United States is 90 mph at 10 meters above the ground (ASCE 7-98 [DIRS 149921], Figure 6-1).

Maximum daily observed 3-second gust wind speed data for the 5-year period of 1998 through 2002 (BSC 2004 [DIRS 166972], Section 4) were collected at the Yucca Mountain 60-m meteorological tower, Site 1, located approximately 1 km south of the North Portal of the Exploratory Studies Facility. This location represents terrain exposure similar to that of the planned surface facility area on the western side of Midway Valley (BSC 2003 [DIRS 163158], Addendum A).

The input data for the 5-year period was analyzed in accordance with the process presented in BSC (2004 [DIRS 166972], Section 6). The estimated basic wind speed of a 3-second gust, the standard deviation, and the upper 90 percent confidence interval speed for the 50- and 100-year return periods are presented in Table 6.1.1-4 (BSC 2004 [DIRS 166972], Table 6-3). This analysis was performed to determine whether estimates of extreme wind speeds, using onsite data, exceeded default values.

Table 6.1.1-4. Site 1 Basic Wind Speed Calculations at 10 Meters Above Ground Level

Recurrence Interval (Years)	Mean Basic Wind Speed (mph)	Upper 90% Confidence Interval (mph)	Three Standard Deviations Above Mean (mph)
50	66.3	72.0	76.4
100	68.9	75.2	80.1

Source: BSC 2004 [DIRS 166972], Table 6-3

These results show that the calculated and observed values taken from five years of onsite data support use of the nominal design 3-second gust wind speed of 90 mph shown in ASCE 7-98 [DIRS 149921], Figure 6-1 (BSC 2004 [DIRS 166972], Section 7).

6.1.1.3 Tornadoes

See Section 4.2.2.3.7.

6.1.1.4 Lightning

See Section 4.3.1.5.

6.1.1.5 Ambient Temperature

Criteria—The system shall be designed to withstand and operate in the extreme outside (surface) temperature environment of 2°F to 116°F (-17°C to 47°C) (DTN: MO0211HISTMPEX.000 [DIRS 161983]).

Technical Rationale—This criterion establishes the outdoor temperature environment in which SSCs are expected to operate. Temperature is considered to be one of the primary environmental parameters that can effect component performance or result in advanced degradation. The extreme outside temperature range (2°F to 116°F) is determined based on a survey of records (1998 to 2002) for nine meteorological monitoring sites located at Yucca Mountain (DTN: MO0405XTMP9802.000 [DIRS 169326]) and three nearby National Oceanic and Atmospheric Administration stations (Beatty, Amargosa Farms, and Desert Rock WSMO) located in the area surrounding Yucca Mountain (DTN: MO0211HISTMPEX.000 [DIRS 161983]).

6.1.1.6 Humidity

Criteria—The system shall be designed to withstand and operate in the surface external relative humidity environment described in Table 6.1.1-5.

Table 6.1.1-5. Surface External Relative Humidity Environment

Parameter	Value[a]
Annual mean value	30%
Minimum summer monthly mean value (June)	11%
Maximum winter monthly mean value (December)	58%

Source: DTN: MO0405SEPRHVMM.000 [DIRS 170462].

NOTE: [a]Values rounded to the nearest whole percent.

Technical Rationale—Humidity is considered to be a primary environmental parameter that can affect performance and anticipated life expectancy of SSCs. This criterion establishes the external humidity environment at the site. The site-specific values are based on an updated analysis of Site 1 records that includes the period from 1998 to 2002 (DTN: MO0405SEPRHVMM.000 [DIRS 170462]).

6.1.1.7 Frost Line

Criteria—The system shall be designed to withstand a potential penetration depth of 15 in.

Technical Rationale—Frost line is one of the external environmental parameters that can affect the foundation and footing design for the structures that must be embedded in the ground. The frost line depth will be based on the conditions at the Nevada Test Site. This information is referenced in *Supplemental Soils Report* (BSC 2004 [DIRS 166067], Section 11.11).

6.1.2 Hydrological

6.1.2.1 Flood Events

Criteria—Flooding consequences associated with flooding shall be as identified in BSC (2004 [DIRS 169464]). Man-made channels will be sized to transport the probable maximum flood around the North Portal pad. Berms will be added where necessary to ensure that probable maximum flood elevations do not affect the facilities.

Technical Rationale—Conclusions or recommendations from *Hydrologic Engineering Studies for the North Portal Pad and Vicinity* (BSC 2004 [DIRS 169464]) support this criterion. Flooding consequences associated with flooding shall be as identified in *Hydrologic Engineering Studies for the North Portal Pad and Vicinity* (BSC 2004 [DIRS 169464]).

6.1.3 Seismic

Seismic design input for the design of SSCs ITS at the repository are provided in terms of Acceleration Response Spectra, and Acceleration Time Histories at locations B, C, D, and E are defined in Figure 6.1.3-1. Locations B and C correspond to the design of subsurface facilities, whereas Locations D and E correspond to the design of surface facilities.

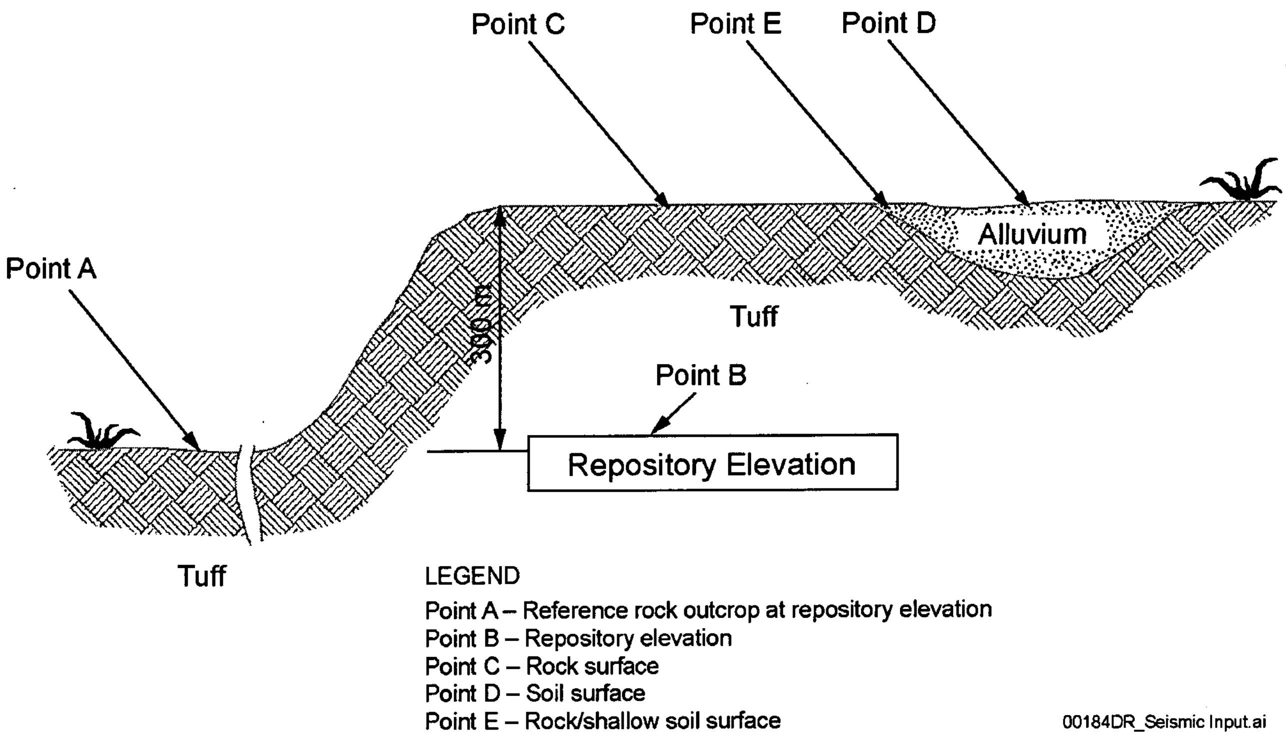

Figure 6.1.3-1. Seismic Design Input Locations

The seismic input generated for SSCs ITS are for different annual probability of occurrence of the seismic hazard. Three different levels of seismic ground motions are identified in Table 4.2.2-1.

6.1.3.1 Seismic Input for the Design of Structures, Systems, and Components that are Important to Safety

Criteria—The acceleration response spectra and acceleration time histories for SSCs ITS shall be used from Table 6.1.3-1.

Table 6.1.3-1. Seismic Design Input Identifiers

Location	Seismic Design Input Motion for Mean Annual Probability of Exceedance		
	1E-3 (1,000-Year Return Period)	5E-4 (2,000-Year Return Period)	1E-4 (10,000-Year Return Period)
B	Response Spectrum: DTN: MO0405SDSTPNTB.001 [DIRS 169851] Time History: DTN: MO0405SDSTPNTB.001 [DIRS 169851]	Response Spectrum: DTN: MO0407SDARS104.001 [DIRS 170683] Time History: DTN: MO0407TMHIS104.003 [DIRS 170599]	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)
C	Response Spectrum: DTN: (to be provided later) Time History: DTN: (to be provided later)	Response Spectrum: Figures (to be provided later) Time History: DTN (to be provided later)	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)
D/E	Response Spectrum: DTN: MO0411SDSDE103.003 [DIRS 172425] Time History: DTN: MO0411SDSDE103.003 [DIRS 172425]	Response Spectrum: DTN: MO0411SDSTMHIS.006 [DIRS 172426] Time History: DTN: MO0411SDSTMHIS.006 [DIRS 172426]	Response Spectrum: DTN: MO0411WHBDE104.003 [DIRS 172427] Time History: DTN: MO0411WHBDE104.003 [DIRS 172427]

Technical Rationale—The acceleration response spectra and time histories provided in the table are based on site-specific information.

6.1.3.2 Seismic Input for the Design of Conventional Structures, Systems, and Components

6.1.3.2.1 Non-SC Surface SSCs

Criteria—The non-SC surface SSCs shall be designed for the requirements of the IBC (ICC 2000 [DIRS 159179], Section 1615). The location of the North Portal is N765352.70, E569814.37 (YMP 2005 [DIRS 172983]), which corresponds to 36.85° N Latitude and 116.43° W Longitude.

The design acceleration spectra for the non-SC surface SSCs shall be developed using the approach given in the IBC (ICC 2000 [DIRS 159179]) and the following approach:

1. Determine the site-specific surface spectra for 2,500 return period for 5 percent damping. These spectra will correspond to the "maximum considered earthquake" in the IBC (ICC 2000 [DIRS 159179]).

2. Apply the two-thirds factor to the 2,500-year return period accelerations to obtain the approximate 500-year return period design parameters.

3. When the scaled spectra are obtained, reduce the short period acceleration to the peak ground acceleration at and above 33 Hz.

4. Smooth the spectra to obtain straight lines in the acceleration, velocity, and displacement regions (on a log-log scale).

Technical Rationale—This is required in the IBC (ICC 2000 [DIRS 159179]).

6.1.3.2.2 Non-SC Subsurface SSCs

Criteria—The non-SC subsurface SSCs shall be designed for the same seismic design input motion as subsurface SC SSCs.

Technical Rationale—This is a conservative seismic design criteria for subsurface SSCs.

6.1.4 Volcanoes

Criteria—Volcanic ash fall structural design criteria shall be presented in Section 4.2.2.3.4.

Technical Rationale—Ash load is based on *MGR External Events Hazards Screening Analysis* (BSC 2004 [DIRS 167266], Section 6.4.53).

6.1.5 Radon

See Section 4.8.3.11.

6.1.6 Silica Dust

Criteria—The silica dust criteria requires that airborne exposures to crystalline silica shall not exceed the ACGIH TLV of 0.05 mg/m^3 for an eight-hour time-weighted average (ACGIH 2005 [DIRS 173218]). The immediate danger to life and health limit for Cristobolite and Tridymite Silica is 25 mg/m^3, and the immediate danger to life and health limit for quartz is 50 mg/m^3 (NIOSH 1996 [DIRS 147940]).

Technical Rationale—Work performed at the repository will be subject to DOE O 440.1A [DIRS 102288], which invokes the ACGIH TLV requirements. The ACGIH TLV is selected as the standard because it is more restrictive than the OSHA-permissible exposure limit for silica (0.1 mg/m^3) (NIOSH 1996 [DIRS 147940]), and it represents a more protective work environment (DOE O 440.1A [DIRS 102288], Attachment 2, Section 12.g).

6.1.7 Rockfall

Criteria—The subsurface facility shall be designed to minimize rockfall.

Technical Rationale—Rockfall within underground openings as a function of time is a natural and expected occurrence for any subsurface excavation. Over time, changes occur to both the stress condition and the strength of the rock mass due to several interacting factors, which are discussed in the *Drift Degradation Analysis* (BSC 2004 [DIRS 166107]). Rockfall can typically be minimized through appropriate design and construction. Factors for minimizing rockfall include the following:

- Drift orientation—The subsurface opening orientations relative to the orientation of the dominant rock joints effect opening stability. The orientation of emplacement drifts relative to the dominant rock joint is therefore a consideration for ground stability and rockfall. A drift orientation perpendicular to the strike of the dominant joint set will maximize opening stability and minimize rockfall (Section 4.11.2.3.1).

- Drift size—Rockfall increases with increasing drift diameter. The effects of a change in drift diameter on rockfall development in repository emplacement drifts have been quantified (BSC 2002 [DIRS 172986]). The emplacement drift diameter is the nominal opening for use in designing emplacement drift fittings and the mobile equipment that is intended to use the emplacement drifts (Section 4.11.2.4.1).

- Ground support system—The ground support system ensures opening stability is maintained in the range of geologic formations in the repository horizon and for all expected loading conditions, including in situ rock loads, construction, operation, thermal, and seismic loads. Ground support provides protection against rockfall for all subsurface personnel, equipment, and the engineered barrier systems, including the waste packages, during the preclosure period (see Sections 4.5.2.1.5 and 4.5.2.1.6).

- Scaling—Rockfall can be mitigated by scaling, which is the removal of loose rocks from the roof or walls. Scaling is typically done immediately after excavation to identify and prevent potential rockfall hazards.

6.1.8 Structural Geology

Criteria—The subsurface facility shall be located to minimize the effects of fault displacement.

Technical Rationale—The distribution and properties of faults and fractures are important elements of the structural geology of a repository at Yucca Mountain. Faults could impact repository performance by affecting the stability of underground openings, or by acting as pathways for water flow. The repository is an area of known faults, but these faults are inactive and therefore have a limited effect on repository operations. To mitigate possible effects from fault displacement, emplacement drifts will be set back an adequate distance from faults.

6.2 NOT USED

6.3 THERMAL

6.3.1

Criteria—Design of rock pillars between emplacement drifts shall promote the drainage of water (Williams 2002 [DIRS 162731]). This satisfied in part by restricting the nominal drift spacing to 81 m (266 ft), as is required in Section 4.11.2.4.2.

Technical Rationale—This criterion on pillar design is intended to ensure that pore water liberated from the host rock matrix and percolation flux drain through the subboiling region of the fracture network to the water table rather than accumulating above the repository horizon. This is also imposed through the PRD (Canori and Leitner 2003 [DIRS 166275], PRD-014/T-045).

6.3.2

Criteria—Cladding temperature for CSNF handled in the surface facilities shall not exceed 400°C during normal operations and 570°C during off-normal and accident conditions. Cladding temperature for DOE SNF of commercial origin handled in the surface facilities shall not exceed 350°C for zircaloy-clad assemblies and 400°C for stainless steel clad assemblies. Cladding temperature for all SNF shall not exceed 350°C following sealing of the waste package.

Technical Rationale—Cladding temperature is limited to provide a margin to failure by creep rupture. The cladding temperature limits for handling of CSNF in the surface facilities are based on Nuclear Regulatory Commission Interim Staff Guidance-11 (NRC 2003 [DIRS 170332]). The cladding temperature limits for handling of DOE SNF in the surface facilities is based on the PRD (Canori and Leitner 2003 [DIRS 166275], PRD-013/T-040). The 350°C cladding temperature limit for preclosure and postclosure (following sealing of the waste package) is based on "Thermal Inputs for Evaluations Supporting TSPA-LA, Supplement" (Williams 2003 [DIRS 162731]). This value is also mandated by *Repository Design Asset Functional & Operational Requirements and Design Solutions* (DOE 2003 [DIRS 167367], Table I, 1.5.04.02.01).

6.3.3

Criteria—Preclosure emplacement drift wall temperature during normal operations shall be less than 96°C. Emplacement drift wall temperatures shall not exceed 200°C at any time during preclosure, allowing for off-normal events of limited duration.

Technical Rationale—The goal to limit preclosure drift wall temperature to 96°C or less during normal operations is to not preclude cool operating modes (Williams 2003 [DIRS 162731]). The goal to limit drift wall temperature to 200°C or less at any time is to avoid adverse mineralogical transitions in the host rock environment in *Postclosure Modeling and Analyses Design Parameters* (BSC 2004 [DIRS 169885], Table B-1, p. B-4).

6.3.4

Criteria—Postclosure drift wall temperature shall be 200°C or less (Williams 2003 [DIRS 162731]).

Technical Rationale—The goal to limit postclosure drift wall temperature to 200°C or less is to avoid adverse mineralogical transitions in the host rock environment. This is based on *Postclosure Modeling and Analyses Design Parameters* (BSC 2004 [DIRS 169885], Table B-1, p. B-4).

6.3.5

Criteria—The repository shall limit the change in temperature, at 45 cm below the soil surface, to 2°C above what the established naturally occurring preemplacement annual ground surface temperature is within the footprint of the repository.

Technical Rationale—This is a requirement on repository thermal performance established by the DOE and imposed on the YMP through the PRD (Canori and Leitner 2003 [DIRS 166275], PRD-014/T 005 and PRD-014/T-042).

6.3.6

Criteria—The repository shall package SNF and HLW in compliance with a packaging plan such that the thermal load does not exceed 11.8 kW per waste package at the time of emplacement.

Technical Rationale—This limit is part of thermal management design solution to ensure that temperature limits provided in Sections 6.3.1 through 6.3.5 are met. This value is also mandated in *Project Functional and Operational Requirements* (Curry 2004 [DIRS 170557], Requirements 1.1-5a, 1.1.5-1, and 1.1.5-2).

6.3.7

Criteria—The repository shall emplace waste packages in a manner that achieves an average thermal line loading of 1.45 kW/m of emplacement drift length.

Technical Rationale—This limit is part of thermal management design solution to ensure that temperature limits provided in Sections 6.3.1 through 6.3.5 are met. This value is also mandated in *Project Functional and Operational Requirements* (Curry 2004 [DIRS 170557], Requirement 1.1-5d).

6.3.8

Criteria—The postclosure waste package surface temperature shall be kept below 300°C to eliminate postclosure impacts to performance (i.e., phase stability).

Technical Rationale—This requirement is necessary to eliminate postclosure material performance impacts by ensuring phase stability of Alloy 22. This requirement is levied in *Postclosure Modeling and Analyses Design Parameters* (BSC 2004 [DIRS 169885], Section 6.9.3, Table 9, p. 38).

INTENTIONALLY LEFT BLANK

7. REFERENCES

7.1 DOCUMENTS CITED

[DIRS 171910]
Arthur, W.J., III. 2004. "Technical Direction to Bechtel SAIC Company, LLC, Contract Number DE-AC28-01RW12101, Use of J-Wells and C-Wells for Repository Water Sources; TDL No. 04-043." Letter from W.J. Arthur, III (DOE/ORD) to J.T. Mitchell, Jr. (BSC), August 31, 2004, 0902043036, with enclosure. ACC: MOL.20041005.0337; MOL.20041005.0338.

[DIRS 112651]
Bongarra, J.P., Jr.; VanCott, H.P.; Pain, R.F.; Peterson L.R.; and Wallace, R.I. 1985. *Human Factors Design Guidelines for Maintainability of Department of Energy Nuclear Facilities.* UCRL-15673. Livermore, California: Lawrence Livermore National Laboratory. TIC: 206097.

[DIRS 155246]
BSC (Bechtel SAIC Company) 2001. *ANSYS Calculations in Support of Natural Ventilation Parametric Study for SR.* CAL-SVS-HV-000003 REV 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010613.0250.

[DIRS 172986]
BSC (Bechtel SAIC Company) 2002. *Assessment of Drift Diameter Variation on Rock Fall Development.* CAL-EBS-MD-000029 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20020613.0194.

[DIRS 157829]
BSC (Bechtel SAIC Company) 2002. *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project.* ANL-MGR-GE-000003 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021004.0078.

[DIRS 159262]
BSC (Bechtel SAIC Company) 2002. *Soils Report for North Portal Area, Yucca Mountain Project.* 100-00C-WRP0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021015.0323, ENG.20050823.0018.

[DIRS 162448]
BSC (Bechtel SAIC Company) 2003. *Corrosion Evaluation of Steel Ground Support Components.* 800-K0C-TEG0-00300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030224.0001.

[DIRS 165551]
BSC (Bechtel SAIC Company) 2003. *Design Analysis for the Yucca Mountain Project Communications System.* 000-EFR-EC00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030820.0011.

[DIRS 165425]
BSC (Bechtel SAIC Company) 2003. *Longevity of Emplacement Drift Ground Support Materials for LA.* 800-K0C-TEG0-01200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030922.0004, ENG.20050816.0017.

[DIRS 166660]
BSC (Bechtel SAIC Company) 2003. *Subsurface Geotechnical Parameters Report.* 800-K0C-WIS0-00400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040108.0001, ENG.20050816.0020.

[DIRS 163158]
BSC (Bechtel SAIC Company) 2003. *Technical Work Plan for: Meteorological Monitoring and Data Analysis.* TWP-MGR-MM-000001 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20030328.0005.

[DIRS 165572]
BSC (Bechtel SAIC Company) 2003. *Underground Layout Configuration.* 800-P0C-MGR0-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031002.0007, ENG.20050817.0005.

[DIRS 166972]
BSC (Bechtel SAIC Company) 2004. *Basic Wind Speed Estimate.* ANL-MGR-MM-000002 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040310.0005.

[DIRS 172191]
BSC (Bechtel SAIC Company) 2004. *BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages.* 000-30R-WIS0-00200-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041004.0003 .

[[DIRS 166107]
BSC (Bechtel SAIC Company) 2004. *Drift Degradation Analysis.* ANL-EBS-MD-000027 REV 03. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040915.0010; DOC.20050419.0001.

[DIRS 171471]
BSC (Bechtel SAIC Company) 2004. *Extreme Wind/Tornado/Tornado Missile Hazard Analysis.* 000-00C-WHS0-00100-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041105.0001.

[DIRS 172230]
BSC (Bechtel SAIC Company) 2004. *Facility Location Calculation.* 000-C0C-C000-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041006.0016.

[DIRS 168740]
BSC (Bechtel SAIC Company) 2004. *Geologic Repository Operations Area Aging Site Plan.* 170-C00-MGR0-00101-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20040330.0241.

[DIRS 171816]
BSC (Bechtel SAIC Company) 2004. *Geologic Repository Operations Area North Portal Site Plan.* 100-C00-MGR0-00101-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041007.0004.

[DIRS 168178]
BSC (Bechtel SAIC Company) 2004. *Ground Control for Non-Emplacement Drifts for LA.* 800-KMC-SSD0-00700-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040302.0022, ENG.20050816.0022.

[DIRS 170008]
BSC (Bechtel SAIC Company) 2004. *Hydrogeologic Framework Model for the Saturated Zone Site Scale Flow and Transport Model.* MDL-NBS-HS-000024 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041118.0001.

[DIRS 169464]
BSC (Bechtel SAIC Company) 2004 *Hydrologic Engineering Studies for the North Portal Pad and Vicinity.* 000-00C-CD04-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040504.0005, ENG.20050823.0020.

[DIRS 172358]
BSC (Bechtel SAIC Company) 2004. *MGR Overall Water Balance Calculation.* 000-M0C-PSW0-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040709.0017.

[DIRS 167266]
BSC (Bechtel SAIC Company) 2004. *Monitored Geologic Repository External Events Hazards Screening Analysis.* 000-00C-MGR0-00500-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040712.0004.

[DIRS 172171]
BSC (Bechtel SAIC Company) 2004. *Overall Monitored Geologic Repository Site Layout.* 000-C00-MGR0-00101-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041007.0003.

[DIRS 169885]
BSC (Bechtel SAIC Company) 2004. *Postclosure Modeling and Analyses Design Parameters.* TDR-MGR-MD-000037 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041109.0002.

[DIRS 170564]
BSC (Bechtel SAIC Company) 2004. *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain.* TDR-WHS-MD-000004 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040827.0011.

[DIRS 167313]
BSC (Bechtel SAIC Company) 2004. *Preliminary Hazards Analysis for License Application Study.* 000-30R-HPYK-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040610.0002.

[DIRS 171501]
BSC (Bechtel SAIC Company) 2004. *Repository Design Requirements: Safeguards and Security.* TER-MGR-AD-000002 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040805.0002.

[DIRS 166067]
BSC (Bechtel SAIC Company) 2004. *Supplemental Soils Report.* 100-S0C-CY00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041108.0006, ENG.20050823.0021.

[DIRS 174913]
BSC (Bechtel SAIC Company) 2005. *Cask and Waste Package Inerting Systems Calculation.* 100-M0C-MRI0-00100-000 REV 00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050809.0002.

[DIRS 175034]
BSC (Bechtel SAIC Company) 2005. *Cask Cooling System Calculation.* 130-M0C-MRC0-00100-000 Rev. 00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050727.0001.

[DIRS 174467]
BSC (Bechtel SAIC Company) 2005. *Categorization of Event Sequences for License Application.* 000-00C-MGR0-00800-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050808.0003.

[DIRS 174269]
BSC (Bechtel SAIC Company) 2005. *Q-List.* 000-30R-MGR0-00500-000-002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050805.0006.

[DIRS 166275]
Canori, G.F. and Leitner, M.M. 2003. *Project Requirements Document.* TER-MGR-MD-000001 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20031222.0006.

[DIRS 159359]
Cook, R.A. 1999. *Strength Design of Anchorage to Concrete.* Skokie, Illinois: Portland Cement Association. TIC: 252912.

[DIRS 100252]
CRWMS M&O 1997. *Subsurface Waste Package Handling - Remote Control and Data Communication Analysis.* BCA000000-01717-0200-00004 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19970714.0655.

[DIRS 115042]
CRWMS M&O 1999. *TBV-361 Resolution Analysis: Emplacement Drift Orientation.* B00000000-01717-5705-00136 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990802.0316.

[DIRS 167332]
CRWMS M&O 2000. *ESF Sanitary Sewer System Operation and Maintenance Manual.* BA0000000-01717-3500-00003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000912.0214.

[DIRS 165475]
CRWMS M&O 2000. *Potable Water System Operations and Maintenance Manual.* BA0000000-01717-3500-00005 REV 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000830.0341.

[DIRS 170557]
Curry, P.M. 2004. *Project Functional and Operational Requirements.* TDR-MGR-ME-000003 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040714.0003.

[DIRS 170737]
Dixon, W.R. 1997. Application for Permit to Appropriate the Public Waters of the State of Nevada. Serial No. 63263. [Carson City], Nevada: State of Nevada. ACC: MOL.19971124.0428.

[DIRS 170738
Dixon, W.R. 1997. Application for Permit to Appropriate the Public Waters of the State of Nevada. Serial No. 63264. [Carson City], Nevada: State of Nevada. ACC: MOL.19971124.0429.

[DIRS 170739]
Dixon, W.R. 1997. Application for Permit to Appropriate the Public Waters of the State of Nevada. Serial No. 63265. [Carson City], Nevada: State of Nevada. ACC: MOL.19971124.0430.

[DIRS 170740
Dixon, W.R. 1997. Application for Permit to Appropriate the Public Waters of the State of Nevada. Serial No. 63266. [Carson City], Nevada: State of Nevada. ACC: MOL.19971124.0431.

[DIRS 170741]
Dixon, W.R. 1997. Application for Permit to Appropriate the Public Waters of the State of Nevada. Serial No. 63267. [Carson City], Nevada: State of Nevada. ACC: MOL.19971124.0432.

[DIRS 158398]
DOE (U.S. Department of Energy) 2002. *U.S. Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste to the Monitored Geologic Repository.* Volume 1 of *Integrated Interface Control Document.* DOE/RW-0511 Rev. 01. Las Vegas, Nevada: U.S. Department of Energy. ACC: MOL.20020614.0342.

[DIRS 167367]
DOE (U.S. Department of Energy) 2003. *Repository Design Asset Functional & Operational Requirements and Design Solutions.* DOE/RW-0600, Rev. 1. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20040202.0005.

[DIRS 171539]
DOE (U.S. Department of Energy) 2004. *Quality Assurance Requirements and Description.* DOE/RW-0333P, Rev. 16. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20040907.0002.

[DIRS 125707]
Dorf, R.C., ed. 1993. *The Electrical Engineering Handbook.* Boca Raton, Florida: CRC Press. TIC: 209253.

[DIRS 164177]
Edwards, T.A. and Yuan, Y. 2003. *Recommended Surface Contamination Levels for Waste Packages Prior to Placement in the Repository.* 000-30R-OSS0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030903.0001.

[DIRS 101877]
Hartman, H.L.; Mutmansky, J.M.; Ramani, R.V.; and Wang, Y.J. 1997. *Mine Ventilation and Air Conditioning.* 3rd Edition. New York, New York: John Wiley & Sons. TIC: 236391.

[DIRS 167376]
Holt, R. 2004. "Re: Surface Rail Bend Radius." E-mail from R. Holt to J. Heineman, February 5, 2004. ACC: MOL.20040205.0357. TBV-6566

[DIRS 101687]
Johnson, A.B., Jr. 1977. *Behavior of Spent Nuclear Fuel in Water Pool Storage.* BNWL-2256. Richland, Washington: Pacific Northwest Laboratory. TIC: 234703.

[DIRS 169589]
Joy, D.R. 1995. *Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities.* NUREG-1065, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040401.0109.

[DIRS 159274]
Linderman, R.B.; Rotz, J.V.; and Yeh, G.C.K. 1974. *Design of Structures for Missile Impact, Topical Report.* BC-TOP-9-A, Rev. 2. San Francisco, California: Bechtel Power. TIC: 253115.

[DIRS 170673]
Mecham, D.C., ed. 2004. *Waste Package Component Design Methodology Report.* 000-30R-WIS0-00100-000-002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040713.0003.

[DIRS 173265]
Mitchell, J.T., Jr. 2005. "Contract No. DE-AC28-01RW12101 - Response to Contracting Officer Authorization Letter No. 05-001, Improvements and Refinements in the Technical Bases that Support the Safety Analysis Report (SAR)." Letter from J. Mitchell, Jr. (BSC) to B. Hamilton-Ray (DOE/ORD), December 3, 2004, 1203044102, with enclosures. ACC: MOL.20050110.0076.

[DIRS 173469]
Obert, L. and Duvall, W.I. 1967. *Rock Mechanics and the Design of Structures in Rock.* New York, New York: John Wiley & Sons. TIC: 257123.

[DIRS 174516]
RQ-DIR-10, Rev 0. *Requirements Management Program.* Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20050407.0009.

[DIRS 157529]
Williams, R.D. 2001. "Final Biological Opinion for the Effects of Construction, Operation and Monitoring, and Closure of a Geologic Repository at Yucca Mountain, Nye County, Nevada." Letter from R.D. Williams (U.S. Fish and Wildlife Service) to S. Brocoum (DOE), August 28, 2001, File No. 1-5-00-F-518. ACC: MOL.20011011.0219.

[DIRS 161090]
Williams, N.H. 2002. "Transmittal of Deliverable #SFC1020M3, Monitored Geologic Repository (MGR) Site Development Plan (SDP) - Contract No. DE-AC28-01RW12101." Letter from N.H. Williams (BSC) to J.D. Ziegler (DOE/YMSCO), NS:deh 1021024768, October 21, 2002, with enclosures. ACC: MOL.20021113.0373.

[DIRS 166132]
Williams, N.H. 2003. "Contract No. DE-AC28-01RW12101 - Licensing Position-009, Waste Stream Parameters." Letter from N.H. Williams (BSC) to J.D. Ziegler (DOE/ORD), November 13, 2003, 1105039412, with enclosure. ACC: MOL.20031215.0076.

[DIRS 162731]
Williams, N.H. 2003. "Thermal Inputs for Evaluations Supporting TSPA-LA, Supplement." Interoffice memorandum from N.H. Williams (BSC) to Distribution, April 4, 2003, 0205035938, with enclosures. ACC: MOL.20030501.0081. TBV-5342

[DIRS 154386]
YMP (Yucca Mountain Site Characterization Project) 2001. *Reclamation Implementation Plan.* YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

[DIRS 165505]
YMP (Yucca Mountain Site Characterization Project) 2003. *Disposal Criticality Analysis Methodology Topical Report.* YMP/TR-004Q, Rev. 02. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: DOC.20031110.0005.

[DIRS 172983]

YMP (Yucca Mountain Site Characterization Project) 2005. *Exploratory Studies Facility Package 1A Starter Tunnel General Arrangement Plan (Sht 2).* YMP-025-1-MING-MG121, Rev. 05. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: SIT.20050110.0008.

7.2 CODES, STANDARDS, REGULATIONS, PROCEDURES

The listing of any reference in this section does not indicate or imply the use, application, or compliance in part or whole with the document.

[DIRS 173165]
10 CFR 20. 2005 Energy: Standards for Protection Against Radiation. ACC: MOL.20050323.0072.

[DIRS 168928]
10 CFR 430. 2004. Energy: Energy Conservation Program for Consumer Products. Readily available.

[DIRS 158912]
10 CFR 434. 2002 Energy: Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings. TIC: 256941.

[DIRS 168930]
10 CFR 436. 2004 Energy: Federal Energy Management And Planning Programs. Readily available.

[DIRS 165855]
10 CFR 50. 2002 Energy: Domestic Licensing of Production and Utilization Facilities. TIC: 256945.

[DIRS 173313]
10 CFR 61. 2005 Energy: Licensing Requirements for Land Disposal of Radioactive Waste. ACC: MOL.20050523.0020.

[DIRS 173273]
10 CFR 63. 2005 Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. ACC: MOL.20050405.0118.

[DIRS 173375]
10 CFR 71. 2005 Energy: Packaging and Transportation of Radioactive Material. ACC: MOL.20050523.0022.

[DIRS 171253]
10 CFR 72. 2004 Energy: Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste. TIC: 256942.

[DIRS 173379]
10 CFR 73. 2005 Energy: Physical Protection of Plants and Materials. ACC: MOL.20050523.0016.

[[DIRS 173317]
28 CFR 36. 2004 Judicial Administration: Nondiscrimination on the Basis of Disability by Public Accommodations and in Commercial Facilities. ACC: MOL.20050523.0018.

[DIRS 172709]
29 CFR 1910. 2004 Labor: Occupational Safety and Health Standards. ACC: MOL.20050411.0148.

[DIRS 172710]
29 CFR 1926. 2004 Labor: Safety and Health Regulations for Construction. ACC: MOL.20050411.0134.

[DIRS 173316]
30 CFR 36. 2004 Mineral Resources: Approval Requirements for Permissible Mobile Diesel-Powered Transportation Equipment. ACC: MOL.20050411.0359.

[DIRS 173370]
30 CFR 57. 2004 Mineral Resources: Safety and Health Standards--Underground Metal and Nonmetal Mines. ACC: MOL.20050523.0024.

[DIRS 173318]
30 CFR 817. 2004 Mineral Resources: Permanent Program Performance Standards--Underground Mining Activities. ACC: MOL.20050523.0019.

[DIRS 116969]
36 CFR 1191. 1998 Parks, Forests, and Public Property: Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities. ACC: MOL.20050411.0313.

[DIRS 173319]
40 CFR 110. 2004 Protection of Environment: Discharge of Oil. ACC: MOL.20050411.0384.

[DIRS 173320]
40 CFR 112. 2004 Protection of Environment: Oil Pollution Prevention. ACC: MOL.20050411.0380.

[DIRS 173321]
40 CFR 122. 2004 Protection of Environment: EPA Administered Permit Programs: The National Pollutant Discharge Elimination System. ACC: MOL.20050411.0376.

[DIRS 173326]
40 CFR 125. 2004 Protection of Environment: Criteria and Standards for the National Pollutant Discharge Elimination System. ACC: MOL.20050516.0320.

[DIRS 173327]
40 CFR 133. 2004 Protection Environment: Secondary Treatment Regulation. ACC: MOL.20050411.0385.

[DIRS 173328]
40 CFR 136. 2004 Protection of Environment: Guidelines Establishing Test Procedures for the Analysis of Pollutants. ACC: MOL.20050411.0381.

[DIRS 173245]
40 CFR 141. 2004 Protection of Environment: National Primary Drinking Water Regulations. ACC: MOL.20050331.0079.

[DIRS 173351]
40 CFR 143. 2004 Protection of Environment: National Secondary Drinking Water Regulations. ACC: MOL.20050411.0386.

[DIRS 173329]
40 CFR 243. 2004 Protection of Environment: Guidelines for the Storage and Collection of Residential, Commercial, and Institutional Solid Waste. ACC: MOL.20050411.0383.

[DIRS 173330]
40 CFR 246. 2004 Protection of Environment: Source Separation for Materials Recovery Guidelines. ACC: MOL.20050411.0382.

[DIRS 173331]
40 CFR 257. 2004 Protection of Environment: Criteria for Classification of Solid Waste Disposal Facilities and Practices. ACC: MOL.20050411.0387.

[DIRS 173332]
40 CFR 260. 2004 Protection of Environment: Hazardous Waste Management System: General. ACC: MOL.20050411.0388.

[DIRS 174870]
40 CFR 261. 2004 Protection of Environment: Identification and Listing of Hazardous Waste.

[DIRS 173333]
40 CFR 262. 2004 Protection of Environment: Standards Applicable to Generators of Hazardous Waste. ACC: MOL.20050411.0391.

[DIRS 173381]
40 CFR 273. 2004 Protection of Environment: Standards for Universal Waste Management. ACC: MOL.20050411.0389.

[DIRS 173343]
40 CFR 279. 2004 Protection of Environment: Standards for the Management of Used Oil. ACC: MOL.20050411.0390.

[DIRS 173380]
40 CFR 50. 2004 Protection of Environment: National Primary and Secondary Ambient Air Quality Standards. ACC: MOL.20050523.0014.

[DIRS 173345]
47 CFR 15. 2004 Telecommunication: Radio Frequency Devices. ACC: MOL.20050411.0358.

[DIRS 173350]
49 CFR 172. 2004 Transportation: Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements. ACC: MOL.20050523.0025.

[DIRS 173279]
49 CFR 173. 2004 Transportation: Shippers - General Requirements for Shipments and Packagings. ACC: MOL.20050405.0318.

[DIRS 104024]
63 FR 49643. Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition. Executive Order 13101. Readily available.

[DIRS 104026]
64 FR 30851. Greening the Government Through Efficient Energy Management. Executive Order 13123. Readily available.

[DIRS 170198]
64 FR 44639. Developing and Promoting Biobased Products and Bioenergy, Executive Order 13134. Readily available.

[DIRS 154538]
65 FR 24595. Greening the Government Through Leadership in Environmental Management. Executive Order 13148. Readily available.

[DIRS 159949]
66 FR 40571. Energy Efficient Standby Power Devices. Executive Order 13221. Readily available.

[DIRS 156671]
66 FR 55732. Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, NV, Final Rule. 10 CFR Parts 2, 19, 20, 21, 30, 40, 51, 60, 61, 63, 70, 72, 73, and 75. ACC: MOL.20050324.0102.

[DIRS 169910]
AAR (Association of American Railroads) 2004. *Manual of Standards and Recommended Practices.* Washington, D.C.: Association of American Railroads. TIC: 256289.

[DIRS 166338]
AAR S-2043. 2003. *Performance Specification for Trains Used to Carry High-Level Radioactive Material.* [Washington, D.C.]: Association of American Railroads. TIC: 257585.

[DIRS 164304]
AASHTO (American Association of State Highway and Transportation Officials) 2002. *Standard Specifications for Highway Bridges.* 17th Edition – 2002. Washington, D.C.: American Association of State Highway and Transportation Officials. TIC: 254177.

[DIRS 162324]
ACGIH (American Conference of Governmental Industrial Hygienists) 2001. *Industrial Ventilation, A Manual of Recommended Practice.* 24th Edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists. TIC: 254914.

[DIRS 173218]
ACGIH (American Conference of Governmental Industrial Hygienists) 2005. *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices.* Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists. TIC: 257007.

[DIRS 158830]
ACI 201.2R-01. 2001. *Guide to Durable Concrete.* Farmington Hills, Michigan: American Concrete Institute. TIC: 252729.

[DIRS 158831]
ACI 301-99. 1999. *Specifications for Structural Concrete.* Farmington Hills, Michigan: American Concrete Institute. TIC: 252730.

[DIRS 158832]
ACI 318-02/318R-02. 2002. *Building Code Requirements for Structural Concrete (ACI 318-02) and Commentary (ACI 318R-02).* Farmington Hills, Michigan: American Concrete Institute. TIC: 252731.

[DIRS 158833]
ACI 349-01. 2001. *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01).* Farmington Hills, Michigan: American Concrete Institute. TIC: 252732.

[DIRS 158954]
ACI 359-92. 1992. *Code for Concrete Reactor Vessels and Containments.* Detroit, Michigan: American Concrete Institute. TIC: 248553.

[DIRS 118373]
ACI 506.2-95. 1995. *Specification for Shotcrete.* Detroit, Michigan: American Concrete Institute. TIC: 226412.

[DIRS 107079]
ACI 506R-90(95). 1995. *Guide to Shotcrete.* Farmington Hills, Michigan: American Concrete Institute. TIC: 238721.

[DIRS 158925]
ACI 530-02/ASCE 5-02/TMS 402-02. 2002. *Building Code Requirements for Masonry Structures.* Farmington Hills, Michigan: American Concrete Institute. TIC: 252752.

[DIRS 159157]
AISC (American Institute of Steel Construction) 1989. *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, June 1, 1989, with Commentary.* Chicago, Illinois: American Institute of Steel Construction. TIC: 241419.

[DIRS 107063]
AISC (American Institute of Steel Construction) 1997. *Manual of Steel Construction, Allowable Stress Design.* 9th Edition, 2nd Revision, 2nd Impression. Chicago, Illinois: American Institute of Steel Construction. TIC: 240772.

[DIRS 159156]
AISC S303. 2000. *Code of Standard Practice for Steel Buildings and Bridges.* Chicago, Illinois: American Institute of Steel Construction. TIC: 252927.

[DIRS 162264]
Americans with Disabilities Act of 1990. Public Law No. 101-336, Readily available.

[DIRS 126007]
ANSI C84.1-1995. 1995. *Electric Power Systems and Equipment - Voltage Ratings (60 Hz).* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 242358.

[DIRS 124614]
ANSI N13.8-1973. *American National Standard Radiation Protection in Uranium Mines.* New York, New York: American National Standards Institute. TIC: 208902.

[DIRS 102016]
ANSI N14.6-1993. *American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More.* New York, New York: American National Standards Institute. TIC: 236261.

[DIRS 108309]
ANSI N305-1975. *Design Objectives for Highly Radioactive Solid Material Handling and Storage Facilities in a Reprocessing Plant.* New York, New York: American Institute of Chemical Engineers. TIC: 231659.

[DIRS 166977]
ANSI N320-1979. 1993. *Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255416.

[DIRS 164204]
ANSI N42.17B-1989. 1990. *American National Standard Performance Specifications for Health Physics Instrumentation—Occupational Airborne Radioactivity Monitoring Instrumentation.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254161.

[DIRS 161832]
ANSI N42.18-1980 (Reaffirmed 1991). *Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 253917.

[DIRS 173120]
ANSI Z358.1-2004. 2004. *American National Standard for Emergency Eyewash and Shower Equipment.* Arlington, Virginia: International Safety Equipment Association. TIC: 256278.

[DIRS 112938]
ANSI Z535.1-1998. 1998. *Safety Color Code.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 242940.

[DIRS 112430]
ANSI Z535.2-1998. 1998. *Environmental and Facility Safety Signs.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 242942.

[DIRS 158834]
ANSI Z535.3-2002. 2002. *Criteria for Safety Symbols.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 252735.

[DIRS 112910]
ANSI Z535.4-1998. 1998. *Product Safety Signs and Labels.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 242945.

[DIRS 112339]
ANSI Z535.5-1998. 1998. *Accident Prevention Tags (for Temporary Hazards).* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 242949.

[DIRS 114614]
ANSI Z88.2-1992. *American National Standard for Respiratory Protection.* New York, New York: American National Standards Institute. TIC: 233859.

[DIRS 171789]
ANSI/AISC 341-02. 2002. *Seismic Provisions for Structural Steel Buildings.* Chicago, Illinois: American Institute of Steel Construction. TIC: 256615.

[DIRS 158835]
ANSI/AISC N690-1994. 1994. *American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities.* Chicago, Illinois: American Institute of Steel Construction. TIC: 252734.

[DIRS 153079]
ANSI/AMCA 210-99. 2000. *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.* Arlington Heights, Illinois: Air Movement and Control Association International. TIC: 249168.

[DIRS 158949]
ANSI/ANS-15.17-1981. *Fire Protection Program Criteria for Research Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 252754.

[DIRS 103071]
ANSI/ANS-2.8-1992. *American National Standard for Determining Design Basis Flooding at Power Reactor Sites.* La Grange Park, Illinois: American Nuclear Society. TIC: 236034.

[DIRS 151842]
ANSI/ANS-3.11-2000. *American National Standard for Determining Meteorological Information at Nuclear Facilities.* La Grange Park, Illinois: American Nuclear Society. TIC: 248540.

[DIRS 122381]
ANSI/ANS-40.35-1991. *Volume Reduction of Low-Level Radioactive Waste or Mixed Waste.* La Grange Park, Illinois: American Nuclear Society. TIC: 240264.

[DIRS 164322]
ANSI/ANS-40.37-1993. 1994. *American National Standard for Mobile Radioactive Waste Processing Systems.* La Grange Park, Illinois: American Nuclear Society. TIC: 253794.

[DIRS 122378]
ANSI/ANS-55.1-1992. *Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 241063.

[DIRS 166935]
ANSI/ANS-55.4-1993. 1999. *Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plants.* 1993 Edition/Reaf 1999. La Grange Park, Illinois: American Nuclear Society. TIC: 253793.

[DIRS 122354]
ANSI/ANS-55.6-1993. *Liquid Radioactive Waste Processing System for Light Water Reactor Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 243644.

[DIRS 108311]
ANSI/ANS-57.1-1992. 1992. *Design Requirements for Light Water Reactor Fuel Handling Systems.* La Grange Park, Illinois: American Nuclear Society. TIC: 238364.

[DIRS 111337]
ANSI/ANS-57.2-1983. *American National Standard Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 8518.

[DIRS 102564]
ANSI/ANS-57.7-1988. *American National Standard Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type).* Revision of ANSI/ANS 57.7-1981. La Grange Park, Illinois: American Nuclear Society. TIC: 238870.

[DIRS 103093]
ANSI/ANS-57.9-1992. *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type).* La Grange Park, Illinois: American Nuclear Society. TIC: 3043.

[DIRS 158953]
ANSI/ANS-59.3-1992. *Nuclear Safety Criteria for Control Air Systems.* La Grange Park, Illinois: American Nuclear Society. TIC: 252757.

[DIRS 107016]
ANSI/ANS-6.1.1-1977. *Neutron and Gamma-Ray Flux-to-Dose-Rate Factors.* La Grange Park, Illinois: American Nuclear Society. TIC: 239401.

[DIRS 118070]
ANSI/ANS-6.4-1997. *Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 241065.

[DIRS 117482]
ANSI/ANS-6.4.2-1985. *Specification for Radiation Shielding Materials.* La Grange Park, Illinois: American Nuclear Society. TIC: 238361.

[DIRS 100958]
ANSI/ANS-8.1-1983. *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 231616.

[DIRS 123801]
ANSI/ANS-8.1-1998. *Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 242363.

[DIRS 103293]
ANSI/ANS-8.17-1984. *Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 231625.

[DIRS 144743]
ANSI/ANS-8.21-1995. *American National Standard for the Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 247030.

[DIRS 158946]
ANSI/ANS-8.22-1997. *American National Standard for Nuclear Criticality Safety Based on Limiting and Controlling Moderators.* La Grange Park, Illinois: American Nuclear Society. TIC: 235109.

[DIRS 103095]
ANSI/ANS-8.3-1997. *Criticality Accident Alarm System.* La Grange Park, Illinois: American Nuclear Society. TIC: 240265.

[DIRS 159434]
ANSI/ANS-HPSSC-6.8.1-1981. *Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Nuclear Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 253112.

[DIRS 174325]
ANSI/ASHRAE Std 15-2004. 2004. *Safety Standard for Refrigeration Systems.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257064.

[DIRS 169815]
ANSI/ASHRAE 33-2000. 2001. *Method of Testing Forced Circulation Air Cooling and Air Heating Coils.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256175.

[DIRS 174323]
ANSI/ASHRAE Std 34-2004. 2004. *Designation and Safety Classification of Refrigerants.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257065.

[DIRS 164197]
ANSI/ASHRAE 52.1-1992. 1992. *Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air Conditioning Engineers. TIC: 254102.

[DIRS 174322]
ANSI/ASHRAE Std 55-2004. 2004. *Thermal Environmental Conditions for Human Occupancy.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257066.

[DIRS 174320]
ANSI/ASHRAE 62.1-2004. 2004. *Ventilation for Acceptable Indoor Air Quality.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256875.

[DIRS 116968]
ANSI/ASHRAE/IES 90A-a-1987. 1988. *Addenda to Energy Conservation in New Building Design.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 240275.

[DIRS 174321]
ANSI/ASHRAE/IESNA Std 90.1-2004. 2004. *Energy Standard for Buildings Except Low-Rise Residential Buildings.* 1-P Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257067. [DIRS 159557]
ANSI/AWS A2.4-98. 2000. *Standard Symbols for Welding, Brazing, and Nondestructive Examination.* Miami, Florida: American Welding Society. TIC: 253107.

[DIRS 160420]
ANSI/AWS A5.32/A5.32M-97. 1998. *Specification for Welding Shielding Gases.* Miami, Florida: American Welding Society. TIC: 253550.

[DIRS 159556]
ANSI/AWS D14.1-97. 1998. *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment.* Miami, Florida: American Welding Society. TIC: 253132.

[DIRS 164242]
ANSI/AWWA C652-02. 2002. *AWWA Standard for Disinfection of Water-Storage Facilities.* Denver, Colorado: American Water Works Association. TIC: 254108.

[DIRS 160122]
ANSI/AWWA D100-96. 1997. *Welded Steel Tanks for Water Storage.* Denver, Colorado: American Water Works Association. TIC: 253090.

[DIRS 161841]
ANSI/AWWA D102-97. 1997. *Coating Steel Water-Storage Tanks.* Denver, Colorado: American Water Works Association. TIC: 253089.

[DIRS 152380]
ANSI/HPS N13.1. 1999. *American National Standard Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities.* McLean, Virginia: Health Physics Society. TIC: 248835.

[DIRS 173596]
ANSI/ICEA S-80-576-2002. 2002. *ICEA Standard for Category 1 & 2 Individually Unshielded Twisted Pair Indoor Cables (with or without an Overall Shield) for Use in Communications Wiring Systems Technical Requirements.* Carrollton, Georgia: Insulated Cable Engineers Association. TIC: 255908.

[DIRS 173598]
ANSI/ICEA S-87-640-1999. 1999. *ICEA Standard for Optical Fiber Outside Plant Communications Cable.* South Yarmouth, Massachusetts: Insulated Cable Engineers Association. TIC: 255910.

[DIRS 103101]
ANSI/IEEE Std 1008-1987. *IEEE Standard for Software Unit Testing.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 237528.

[DIRS 103098]
ANSI/IEEE Std 1042-1987. *IEEE Guide to Software Configuration Management.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 4460.

[DIRS 164235]
ANSI/IEEE Std 260.1-1993. 1994. *American National Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254112.

[DIRS 171655]
ANSI/IEEE Std 336-1985. 1985. *IEEE Standard Installation, Inspection, and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 242996.

[DIRS 164253]
ANSI/IEEE Std 338-1987. 1988. *IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254139.

[DIRS 159619]
ANSI/IEEE Std 344-1987 (Reaffirmed 1993). *IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.* New York, New York: American National Standards Institute. TIC: 253538.

[DIRS 166684]
ANSI/IEEE Std 944-1986. 1996. *IEEE Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255429.

[DIRS 122135]
ANSI/IES-RP-7-1991. *American National Standard Practice for Industrial Lighting.* New York, New York: Illuminating Engineering Society of North America. TIC: 242936.

[DIRS 122142]
ANSI/IESNA RP-1-1993. *American National Standard Practice for Office Lighting.* New York, New York: Illuminating Engineering Society of North America. TIC: 232650.

[DIRS 166693]
ANSI/IESNA RP-22-96. 1996. *IESNA Recommended Practice for Tunnel Lighting.* New York, New York: Illuminating Engineering Society of North America. TIC: 255084.

[DIRS 173093]
ANSI/IESNA RP-8-00. 2004. *Standard Practice for Roadway Lighting, with Errata.* New York, New York: Illuminating Engineering Society of North America. TIC: 257224.

[DIRS 164201]
ANSI/ISA 67.04.01-2000. 2000. *Setpoints for Nuclear Safety-Related Instrumentation.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254095.

[DIRS 164286]
ANSI/ISA S5.2-1976 (R1992). 1992. *Binary Logic Diagrams for Process Operations.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254079.

[DIRS 166742]
ANSI/ISA-5.1-1984 (R1992). *Instrumentation Symbols and Identification.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 255175.

[DIRS 164191]
ANSI/ISA-50.00.01-1975 (R2002). 2002. *Compatibility of Analog Signals for Electronic Industrial Process Instruments.* Research Triangle Park, North Carolina: Instrumentation, Systems and Automation Society. TIC: 254096.

[DIRS 164220]
ANSI/ISA-S51.1-1979 (R1993) (R1995). 2003. *Process Instrumentation Technology.* Research Triangle Park, North Carolina: Instrumentation, Systems, and Automation Society. TIC: 254109.

[DIRS 164287]
ANSI/ISA-S7.0.01-1996. 1996. *Quality Standard for Instrument Air.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254082.

[DIRS 112340]
ANSI/ISA-S84.01-1996. *Application of Safety Instrumented Systems for the Process Industries.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 244098.

[DIRS 159658]
ANSI/NEMA 250-1997. 2001. *Enclosures for Electrical Equipment (1000 Volts Maximum).* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 253142.

[DIRS 173595]
ANSI/NEMA WC 55-1992, Rev. 2. 1999. *Instrumentation Cables and Thermocouple Wire.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255895.

[DIRS 169804]
ANSI/TIA-568-B.1-5-2004. *Commercial Building Telecommunications Cabling Standard – Part 1: General Requirements – Addendum 5 – Telecommunications Cabling for Telecommunications Enclosures.* Arlington, Virginia: Telecommunications Industry Association. TIC: 256217; 256248; 256249; 256250; 256251; 256252.

[DIRS 170590]
ANSI/TIA-568-B.2-6-2003. *Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components, Addendum 6 – Category 6 Related Component Test Procedures.* Arlington, Virginia: Telecommunications Industry Association. TIC: 256253; 256254; 256255; 256256; 256257; 256258; 256259.

[DIRS 170591]
ANSI/TIA/EIA-568-B.3-1-2002. *Optical Fiber Cabling Components Standard, Addendum 1 - Additional Transmission Performance Specifications for 50/125 um Optical Fiber Cables.* Arlington, Virginia: Telecommunications Industry Association. TIC: 256260; 256261.

[DIRS 159657]
ANSI/UL 467-1998. 2001. *Standard for Grounding and Bonding Equipment.* 7th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 253134.

[DIRS 161103]
ANSI/UL-555-2001. 2002. *Standard for Fire Dampers.* Northbrook, Illinois: Underwriters Laboratory. TIC: 253697.

[DIRS 166749]
API RP 651. 1997. *Cathodic Protection of Aboveground Petroleum Storage Tanks.* 2nd Edition. Washington, D.C.: American Petroleum Institute. TIC: 255138.

[DIRS 169966]
API Std 2000. 1999. *Venting Atmospheric and Low-Pressure Storage Tanks, Nonrefrigerated and Refrigerated, with Errata.* 5th Edition. Washington, D.C.: American Petroleum Institute. TIC: 255217.

[DIRS 164268]
API Std 526. 2003. *Flanged Steel Pressure Relief Valves.* 5th Edition. Washington, D.C.: American Petroleum Institute. TIC: 254087.

[DIRS 164219]
API Std 610. 2003. *Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries.* 9th Edition. Washington, D.C.: American Petroleum Institute. TIC: 254105.

[DIRS 166788]
API Std 619. 1997. *Rotary Type Positive Displacement Compressors for Petroleum, Chemical, and Gas Industry Services.* 3rd Edition. Washington, D.C.: American Petroleum Institute. TIC: 255360.

[DIRS 164240]
API Std 620. 2002. *Design and Construction of Large, Welded, Low-Pressure Storage Tanks.* 10th Edition. Washington, D.C.: American Petroleum Institute. TIC: 254077.

[DIRS 164288]
API Std 650. 2001. *Welded Steel Tanks for Oil Storage, with Addenda 1 and 2.* Washington, D.C.: American Petroleum Institute. TIC: 254089.

[DIRS 169819]
API Std 674. 1995. *Positive Displacement Pumps—Reciprocating.* 2nd Edition. Washington, D.C.: American Petroleum Institute. TIC: 256176.

[DIRS 169818]
API Std 675 (Reaffirmed 2000). 2000. *Positive Displacement Pumps—Controlled Volume.* 2nd Edition. Washington, D.C.: American Petroleum Institute. TIC: 256177.

[DIRS 171657]
AREMA (American Railway Engineering and Maintenance-of-Way Association) 2002. *Manual for Railway Engineering.* [Landover, Maryland]: American Railway Engineering and Maintenance-of-Way Association. TIC: 256146.

[DIRS 164310]
ARI Std 410. 2002. *Forced-Circulation Air-Cooling and Air-Heating Coils, with Addendum.* Arlington, Virginia: Air-Conditioning and Refrigeration Institute. TIC: 254106.

[DIRS 164199]
ARI Std 550/590-98. 1999. *Standard for Water Chilling Packages Using the Vapor Compression Cycle, with Addendum.* Arlington, Virginia: Air-Conditioning & Refrigeration Institute. TIC: 254094.

[DIRS 169217]
ASCE (American Society of Civil Engineers) 1982. *Gravity Sanitary Sewer Design and Construction.* ASCE Manuals and Reports on Engineering Practice No. 60. Reston, Virginia: American Society of Civil Engineers. TIC: 254192.

[DIRS 132149]
ASCE (American Society of Civil Engineering) 1991. *Design and Construction of Sanitary and Storm Sewers.* 6th Printing. [New York, New York]: American Society of Civil Engineers. TIC: 4191.

[DIRS 159618]
ASCE 4-98. 2000. *Seismic Analysis of Safety-Related Nuclear Structures and Commentary.* Reston, Virginia: American Society of Civil Engineers. TIC: 253158.

[DIRS 149921]
ASCE 7-98. 2000. *Minimum Design Loads for Buildings and Other Structures.* Revision of ANSI/ASCE 7-95. Reston, Virginia: American Society of Civil Engineers. TIC: 247427.

[DIRS 174692]
ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers) 2005. *2005 ASHRAE® Handbook, Fundamentals.* Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air Conditioning Engineers. TIC: 257499.

[DIRS 157789]
ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers) 2001. *2001 ASHRAE Handbook, Fundamentals.* Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 249910.

[DIRS 171798]
ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineer 2003. *2003 ASHRAE® Handbook, Heating, Ventilating, and Air-Conditioning Applications.* Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256642.

[DIRS 171799]
ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers). 2004. *2004 ASHRAE Handbook, Heating, Ventilating, and Air-Conditioning Systems and Equipment.* Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256641

[DIRS 169817]
ASHRAE 111-1988. 1997. *Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems, with Errata.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256165 .

[DIRS 124644]
ASHRAE DG-1-93. 1993. *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 240280.

[DIRS 158115]
ASME (American Society of Mechanical Engineers) 2001. *2001 ASME Boiler and Pressure Vessel Code (includes 2002 addenda).* New York, New York: American Society of Mechanical Engineers. TIC: 251425.

[DIRS 171846]
ASME (American Society of Mechanical Engineers) 2004. *2004 ASME Boiler and Pressure Vessel Code.* 2004 Edition. New York, New York: American Society of Mechanical Engineers. TIC: 256479.

[DIRS 166908]
ASME AG-1-2003. *Code on Nuclear Air and Gas Treatment.* New York, New York: American Society of Mechanical Engineers. TIC: 255464.

[DIRS 165262]
ASME B16.3-1998. 1999. *Malleable Iron Threaded Fittings, Classes 150 and 300.* New York, New York: American Society of Mechanical Engineers. TIC: 254936.

[DIRS 165903]
ASME B16.34-1996. 1997. *Valves—Flanged, Threaded, and Welding End.* New York, New York: American Society of Mechanical Engineers. TIC: 254938.

[DIRS 165266]
ASME B16.34a-1998. 1998. *Addenda to ASME B16.34-1996 Valves — Flanged, Threaded, and Welding End.* New York, New York: American Society of Mechanical Engineers. TIC: 254937.

[DIRS 148269]
ASME B16.5-1996. 1997. *Pipe Flanges and Flanged Fittings, NPS ½ Through NPS 24.* New York, New York: American Society of Mechanical Engineers. TIC: 247954.

[DIRS 164190]
ASME B16.5a-1998. 1998. *Addenda to ASME B16.5-1996 Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24.* New York, New York: American Society of Mechanical Engineers. TIC: 254184.

[DIRS 164308]
ASME B30.10-1999. 2000. *Hooks.* New York, New York: American Society of Mechanical Engineers. TIC: 254180.

[DIRS 171687]
ASME B30.16-2003. 2003. *Overhead Hoists (Underhung).* New York, New York: American Society of Mechanical Engineers. TIC: 256188.

[DIRS 171685]
ASME B30.2-2001. 2002. *Overhead and Gantry Cranes {Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist}.* New York, New York: American Society of Mechanical Engineers. TIC: 256189.

[DIRS 171688]
ASME B30.20-2003. 2003. *Below-the-Hook Lifting Devices.* New York, New York: American Society of Mechanical Engineers. TIC: 256185.

[DIRS 169813]
ASME B30.5a-2002. *Addenda to ASME B30.5-2000, Mobile and Locomotive Cranes.* New York, New York: American Society of Mechanical Engineers. TIC: 256168; 256169.

[DIRS 171686]
ASME B30.9-2003. 2003. *Slings.* New York, New York: American Society of Mechanical Engineers. TIC: 256186.

[DIRS 158914]
ASME B31.1-2001. 2001. *Power Piping.* New York, New York: American Society of Mechanical Engineers. TIC: 252760.

[DIRS 158915]
ASME B31.3-2002. 2002. *Process Piping.* New York, New York: American Society of Mechanical Engineers. TIC: 252761.

[DIRS 166013]
ASME B46.1-2002. 2003. *Surface Texture (Surface Roughness, Waviness and Lay).* New York, New York: American Society of Mechanical Engineers. TIC: 257359.

[DIRS 165719]
ASME B73.1-2001. 2002. *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process.* New York, New York: American Society of Mechanical Engineers. TIC: 254619.

[DIRS 167092]
ASME MFC-3M-1989 Reaffirmed 1995. *Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi.* New York, New York: American Society of Mechanical Engineers. TIC: 255045.

[DIRS 167093]
ASME MFC-8M-2001. *Fluid Flow in Closed Conduits: Connections for Pressure Signal Transmissions Between Primary and Secondary Devices.* 2001 Edition. New York, New York: American Society of Mechanical Engineers. TIC: 255538.

[DIRS 115139]
ASME N509-1989. *Nuclear Power Plant Air-Cleaning Units and Components.* New York, New York: American Society of Mechanical Engineers. TIC: 240273.

[DIRS 115203]
ASME N510-1989. *Testing of Nuclear Air Treatment Systems.* New York, New York: American Society of Mechanical Engineers. TIC: 239028.

[DIRS 158891]
ASME NOG-1-2002. 2002. *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder).* New York, New York: American Society of Mechanical Engineers. TIC: 252907.

[DIRS 159544]
ASME NQA-1-2000. 2001. *Quality Assurance Requirements for Nuclear Facility Applications.* New York, New York: American Society of Mechanical Engineers. TIC: 253110.

[DIRS 167090]
ASME PTC 19.3-1974 Reaffirmed 1998. *Part 3, Temperature Measurement, Instruments and Apparatus, Supplement to ASME Performance Test Codes.* New York, New York: American Society of Mechanical Engineers. TIC: 255534.

[DIRS 159536]
ASME Y14.36M-1996. 1996. *Surface Texture Symbols.* New York, New York: American Society of Mechanical Engineers. TIC: 253104.

[DIRS 159534]
ASME Y14.38-1999. *Abbreviations and Acronyms.* New York, New York: American Society of Mechanical Engineers. TIC: 253105.

[DIRS 159535]
ASME Y14.5M-1994. 1999. *Dimensioning and Tolerancing.* New York, New York: American Society of Mechanical Engineers. TIC: 253106.

[DIRS 158933]
ASTM A 108-99. 1999. *Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252772.

[DIRS 157994]
ASTM A 185-01. 2002. *Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252290.

[DIRS 148262]
ASTM A 234/A234M-99. 1999. *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 247687.

[DIRS 165005]
ASTM A 242/A 242M-03a. 2003. *Standard Specification for High-Strength Low-Alloy Structural Steel.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 254844.

[DIRS 165006]
ASTM A 276-03. 2003. *Standard Specification for Stainless Steel Bars and Shapes.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 254842.

[DIRS 154217]
ASTM A 307-00. 2000. *Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 249502.

[DIRS 158936]
ASTM A 325-02. 2002. *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252765.

[DIRS 169609]
ASTM A 36/A 36M-04. 2004. *Standard Specification for Carbon Structural Steel.* West Conshohocken, Pennsylvania: American Society of Testing and Materials. TIC: 256111.

[DIRS 174875]
ASTM A 392-03. 2003. *Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 257190.

[DIRS 158937]
ASTM A 490-02. 2002. *Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252766.

[DIRS 158930]
ASTM A 500-01a. 2001. *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252768.

[DIRS 162719]
ASTM A 53/A 53M-02. 2002. *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 253988.

[DIRS 169820]
ASTM A 571/A 571M-01. 2002. *Standard Specification for Austenitic Ductile Iron Castings for Pressure-Containing Parts Suitable for Low-Temperature Service.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 256174.

[DIRS 165008]
ASTM A 588/A 588M-03. 2003. *Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345MPa] Minimum Yield Point to 4–in. [100–mm] Thick.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 254843.

[DIRS 158033]
ASTM A 615/A 615M-01b. 2001. *Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252480.

[DIRS 158934]
ASTM A 653/A 653M-01a. 2001. *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252770.

[DIRS 159360]
ASTM A 706/A 706 M-01. 2001. *Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252911.

[DIRS 159971]
ASTM A 759-00. 2001. *Standard Specification for Carbon Steel Crane Rails.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 253176.

[DIRS 158841]
ASTM A 820-01. 2001. *Standard Specification for Steel Fibers for Fiber-Reinforced Concrete.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252737.

[DIRS 158926]
ASTM A 992/A 992M-02. 2002. *Standard Specification for Structural Steel Shapes.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252771.

[DIRS 169821]
ASTM B 359/B 359M-02. 2002. *Standard Specification for Copper and Copper-Alloy Seamless Condenser and Heat Exchanger Tubes with Integral Fins.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 256174.

[DIRS 158684]
ASTM C 1116-97. 1998. *Standard Specification for Fiber-Reinforced Concrete and Shotcrete.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 242992.

[DIRS 158842]
ASTM C 1217-00. 2000. *Standard Guide for Design of Equipment for Processing Nuclear and Radioactive Materials.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252738.

[DIRS 158843]
ASTM C 1240-01. 2001. *Standard Specification for Use of Silica Fume as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252739.

[DIRS 158105]
ASTM C 150-02. 2002. *Standard Specification for Portland Cement.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252481.

[DIRS 154218]
ASTM C 494/C 494M-99a. 1999. *Standard Specification for Chemical Admixtures for Concrete.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 249505.

[DIRS 108328]
ASTM C992-89 (Reapproved 1997). *Standard Specification for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Spent Fuel Storage Racks.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 238942.

[DIRS 164216]
ASTM D 1557-02. 2003. *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 254263.

[DIRS 158844]
ASTM D 5144-00. 2000. *Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252740.

[DIRS 171651]
ASTM D 975-04b. 2004. *Standard Specification for Diesel Fuel Oils.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: On Order. TBV-6507

[DIRS 173416]
ASTM E 108-04. 2004. *Standard Test Methods for Fire Tests of Roof Coverings.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 257143.

[DIRS 158845]
ASTM E 136-99. 2000. *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252741.

[DIRS 161348]
ASTM E 84-98. 1998. *Standard Test Method for Surface Burning Characteristics of Building Materials.* Philadelphia, Pennsylvania: American Society for Testing and Materials. TIC: 241077

[DIRS 158931]
ASTM F 1554-99. 1999. *Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252773.

[DIRS 165010]
ASTM F 432-95 (Reapproved 2001). 1995. *Standard Specification for Roof and Rock Bolts and Accessories.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 253986.

[DIRS 157203]
AWS D1.1/D1.1M:2002. 2002. *Structural Welding Code—Steel.* 18th Edition. Miami, Florida: American Welding Society. TIC: 251437.

[DIRS 159555]
AWS D1.6:1999. *Structural Welding Code—Stainless Steel.* Miami, Florida: American Welding Society. TIC: 253130.

[DIRS 150790]
AWWA (American Water Works Association). 1990. *Recommended Practice for Backflow Prevention and Cross-Connection Control.* 2nd Edition. AWWA Manual M14. Denver, Colorado: American Water Works Association. TIC 248200.

[DIRS 164147]
Baker, F. 1995. *Requirements for IP Version 4 Routers.* RFC 1812. [Reston, Virginia: Internet Society]. TIC 254959.

[DIRS 164489]
Cain, B.; Deering, S.; Kouvelas, I.; Fenner, B.; and Thyagarajan, A. 2002. *Internet Group Management Protocol, Version 3.* RFC 3376. [Reston, Virginia]: Internet Society. TIC: 254661.

[DIRS 166901]
CGA G-10.1-1997. *Commodity Specification for Nitrogen.* 5th Edition. Arlington, Virginia: Compressed Gas Association. TIC 255437.

[DIRS 166902]
CGA G-11.1-1998. *Commodity Specification for Argon.* 5th Edition. Arlington, Virginia: Compressed Gas Association. TIC 255438.

[DIRS 164246]
CGA G-7.1-1997. *Commodity Specification for Air.* 4th Edition. Arlington, Virginia: Compressed Gas Association. TIC 254093.

[DIRS 166900]
CGA G-9.1-1998. *Commodity Specification for Helium.* 5th Edition. Arlington, Virginia: Compressed Gas Association. TIC 255436.

[DIRS 170604]
CGA P-18-1992 Reaffirmed 2003. *Standard for Bulk Inert Gas Systems at Consumer Sites.* 1st Edition. Chantilly, Virginia: Compressed Gas Association. TIC 255399.

[DIRS 166794]
CGA P-9-2001. 2001. *The Inert Gases: Argon, Nitrogen, and Helium.* 3rd Edition. Chantilly, Virginia: Compressed Gas Association. TIC 255315.

[DIRS 166905]
CGA V-1-2003. *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.* 11th Edition. Chantilly, Virginia: Compressed Gas Association. TIC 255442.

[DIRS 160411]
Clean Air Act. 42 U.S.C. 7401 et seq. Readily available.

[DIRS 160406]
Clean Water Act of 1977. 33 U.S.C. 1251 et seq. Readily available.

[DIRS 153997]
CMAA 70-2000 . *Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes.* Charlotte, North Carolina: Crane Manufacturers Association of America. TIC 249445.

[DIRS 154319]
CMAA-74-2000. *Specifications for Top Running & Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist.* Charlotte, North Carolina: Crane Manufacturers Association of America. TIC 249651.

[DIRS 171615]
Compressed Gas Association. 2003. *Handbook of Compressed Gases.* 4th Edition. Boston, Massachusetts: Kluwer Academic Publishers. TIC: 256046.

[DIRS 166818]
Deering, S. and Hinden, R. 1998. *Internet Protocol, Version 6 (IPv6) Specification.* RFC 2460. [Reston, Virginia]: Internet Society. TIC 255474.

[DIRS 159667]
DOE G 420.1-1. 2000. *Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for Use with DOE O 420.1, Facility Safety.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 144423]
DOE G 440.1-5. 1995. *Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety Program.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 159140]
DOE HQ O 250.1. 1998. *Civilian Radioactive Waste Management Facilities - Exemption from Departmental Directives.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 159139]
DOE O 252.1. 1999. *Technical Standards Program.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 152047]
DOE O 413.3. 2000. *Program and Project Management for the Acquisition of Capital Assets.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 159450]
DOE O 420.1A. 2002. *Facility Safety.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 158913]
DOE O 430.2A. 2002. *Departmental Energy and Utilities Management.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 102288]
DOE O 440.1A. 1998. *Worker Protection Management for DOE Federal and Contractor Employees.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 161567]
DOE O 450.1. 2003. *Environmental Protection Program.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 170491]
DOE-HDBK-1140-2001. *Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 167097]
DOE-HDBK-1169-2003. *Nuclear Air Cleaning Handbook.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 159258]
DOE-STD-1020-2002. 2002. *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities.* Washington, D.C.: U.S. Department of Energy. TIC 253058.

[DIRS 150357]
DOE-STD-1027-92. 1992. *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.* Washington, D.C.: U.S. Department of Energy. TIC 205819.

[DIRS 154954]
DOE-STD-1066-99. 1999. *Fire Protection Design Criteria.* Washington, D.C.: U.S. Department of Energy. TIC 249884.

[DIRS 169284]
DOE-STD-1090-2001. *Hoisting and Rigging (Formerly Hoisting and Rigging Manual).* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 161223]
DOE-STD-3020-97. 1997. *Specification for HEPA Filters Used by DOE Contractors.* Washington, D.C.: U.S. Department of Energy. Readily available.

[DIRS 164544]
DOT (U.S. Department of Transportation) 1994. *Heliport Design.* Advisory Circular 150/5390-2A. Washington, D.C.: U.S. Department of Transportation, Federal Aviation Administration. TIC 254292.

[DIRS 164546]
DOT (U.S. Department of Transportation) 2001. *MUTCD 2000 Manual on Uniform Traffic Control Devices.* Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration. TIC 254179.

[DIRS 164144]
Droms, R. 1993. *Dynamic Host Configuration Protocol.* RFC 1541. [Reston, Virginia: Internet Society]. TIC 254630.

[DIRS 169219]
EPA (U.S. Environmental Protection Agency) 1980. *Design Manual, Onsite Wastewater Treatment and Disposal Systems. EPA 625/1-80-012.* Washington, D.C: U.S. Environmental Protection Agency, Office of Water Program Operations. TIC 210299.

[DIRS 161330]
EPRI (Electric Power Research Institute) 1991. *A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1).* EPRI NP-6041-SL, Rev. 1. Palo Alto, California: Electric Power Research Institute. TIC 253771.

[DIRS 131950]
Federal Mine Safety and Health Act of 1977. 30 U.S.C. 801 et seq. Readily available.

[DIRS 173418]
FM 4471. 1995. *Approval Standard for Class I Panel Roofs.* [Johnston, Rhode Island]: Factory Mutual Research Corporation. TIC: 257160.

[DIRS 166830]
Freed, N. 2000. *Behavior of and Requirements for Internet Firewalls.* RFC 2979. [Reston,-Virginia]: Internet Society. TIC 255477.

[DIRS 166886]
Grossman, D. 2002. *New Terminology and Clarifications for Diffserv.* RFC 3260. [Reston,-Virginia]: Internet Society. TIC 255482.

[DIRS 159179]
ICC (International Code Council) 2000. *International Building Code 2000.* Falls Church, Virginia: International Code Council. TIC 251054.

[DIRS 159180]
ICC (International Code Council) 2000. *International Plumbing Code, 2000.* Falls Church, Virginia: International Code Council. TIC 253029.

[DIRS 159660]
ICC (International Code Council) 2002. *International Fire Code, 2000.* Falls Church, Virginia: International Code Council. TIC 253149.

[DIRS 158846]
ICC/ANSI A117.1-1998. 2001. *Accessible and Usable Buildings and Facilities.* Falls Church, Virginia: International Code Council. TIC 252742.

[DIRS 173597]
ICEA S-83-596-2001. 2001. *Standard for Optical Fiber Premises Distribution Cable.* 3rd Edition. Carrollton, Georgia: Insulated Cable Engineers Association. TIC: 255909.

[DIRS 103113]
IEEE 1012-1998. *IEEE Standard for Software Verification and Validation Plans.* New York, New York: Institute of Electrical and Electronics Engineers. TIC 242865.

[DIRS 103112]
IEEE 1028-1997. 1998. *IEEE Standard for Software Reviews.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC 242864.

[DIRS 166836]
IEEE 802.1Q™, 2003 Edition. 2003. *IEEE Standards for Local and Metropolitan Area Networks, Virtual Bridged Local Area Networks.* New York, New York: Institute of Electrical and Electronics Engineers. TIC 255471.

[DIRS 158848]
IEEE C2-2002. 2001. *National Electrical Safety Code.* New York, New York: Institute of Electrical and Electronic Engineers. TIC: 252743.

[DIRS 124974]
IEEE Std 1023-1988. *IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC 246808.

[DIRS 169311]
IEEE Std 1048™-2003. 2003. *IEEE Guide for Protective Grounding of Power Lines.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255933.

[DIRS 169773]
IEEE Std 1050-1996. 1999. *Corrections to IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257452.

[DIRS 169768]
IEEE Std 1074-1997. 1998. *IEEE Standard for Developing Software Life Cycle Processes.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256117.

[DIRS 158849]
IEEE Std 1100-1999. 1999. *IEEE Recommended Practice for Powering and Grounding Electronic Equipment.* New York, New York: Institute of Electrical and Electronic Engineers. TIC: 252744.

[DIRS 169312]
IEEE Std 1115-2000. *IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255934.

[DIRS 166786]
IEEE Std 112-1996. 1998. *IEEE Standard Test Procedure for Polyphase Induction Motors and Generators, with Correction Sheet.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255364.

[DIRS 164267]
IEEE Std 1184-1994. 1995. *IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254113.

[DIRS 173592]
IEEE Std 1188-1996. 1996. *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257250.

[DIRS 166681]
IEEE Std 1189-1996. 1996. *IEEE Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255426.

[DIRS 160800]
IEEE Std 1202-1991. *IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 253647.

[DIRS 173725]
IEEE Std 1205-2000. 2000. *IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257184.

[DIRS 164225]
IEEE Std 1289-1998. 1998. *IEEE Guide for the Application of Human Factors Engineering in the Design of Computer-Based Monitoring and Control Displays for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254140.

[DIRS 122242]
IEEE Std 141-1993. 1994. *IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 240362.

[DIRS 122245]
IEEE Std 142-1991. 1991. *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 235220.

[DIRS 164228]
IEEE Std 208-1995. 1995. *IEEE Standard on Video Techniques: Measurement of Resolution of Camera Systems, 1993 Techniques.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254155.

[DIRS 169314]
IEEE Std 241-1990. (Reaffirmed in 1997). 1998. *IEEE Recommended Practice for Electric Power Systems in Commercial Buildings.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255956.

[DIRS 158850]
IEEE Std 242-2001. 2001 . *IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.* New York, New York: The Institute of Electrical and Electronic Engineers. TIC: 252745.

[DIRS 166907]
IEEE Std 323™-2003. 2004. *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255697.

[DIRS 166688]
IEEE Std 379-2000. 2001. *IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255427.

[DIRS 171695]
IEEE Std 383™-2003. 2004. *Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256201.

[DIRS 103105]
IEEE Std 384-1992. 1992. *IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 237497.

[DIRS 122246]
IEEE Std 399-1997. 1998. *IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 242962.

[DIRS 125763]
IEEE Std 446-1995. 1995. *IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 242952.

[DIRS 171696]
IEEE Std 450™-2002. 2003. *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256581.

[DIRS 169128]
IEEE Std 484™-2002. 2003. *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256025.

[DIRS 145528]
IEEE Std 485-1997. *IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 247200.

[DIRS 169803]
IEEE Std 515™-2004. 2004. *IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.* New York, New York: Institute of Electrical and Electronic Engineers. TIC: 256235.

[DIRS 164198]
IEEE Std 519-1992. 1993. *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254111.

[DIRS 169316]
IEEE Std 524™-2003. 2004. *IEEE Guide to the Installation of Overhead Transmission Line Conductors.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255989.

[DIRS 169318]
IEEE Std 525-1992. 1993. *IEEE Guide for the Design and Installation of Cable Systems in Substations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255930.

[DIRS 125916]
IEEE Std 603-1998. *IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 242993.

[DIRS 145720]
IEEE Std 650-1990. 1991. *IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 247148.

[DIRS 173591]
IEEE Std 665-1995. 2001. *IEEE Guide for Generating Station Grounding.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257258.

[DIRS 170777]
IEEE Std 7-4.3.2™-2003. *IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256291.

[DIRS 116978]
IEEE Std 739-1995. 1996. *IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 231563.

[DIRS 125903]
IEEE Std 741-1997. 1997. *IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 242242.

[DIRS 170498]
IEEE Std 751-1991. *IEEE Trial-Use Design Guide for Wood Transmission Structures.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256264.

[DIRS 164256]
IEEE Std 80-2000. 2000. *IEEE Guide for Safety in AC Substation Grounding*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254157.

[DIRS 164133]
IEEE Std 802.11b-1999. 2000. *Supplement to IEEE Standard for Information Technology–Telecommunications and Information Exchange Between Systems–Local and Metropolitan Area Networks–Specific Requirements–Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254397.

[DIRS 172992]
IEEE Std 802.11j™-2004. 2004. *IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan Area Networks-Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, Amendment 7: 4.9 GHz-5 GHz Operation in Japan.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257032.

[DIRS 172990]
IEEE Std 802.3ah™-2004. 2004. *IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan-Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications. Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257033.

[DIRS 102325]
IEEE Std 81-1983. *IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 232605.

[DIRS 145986]
IEEE Std 828-1998. *IEEE Standard for Software Configuration Management Plans.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 247962.

[DIRS 145988]
IEEE Std 829-1998. *IEEE Standard for Software Test Documentation.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 247961.

[DIRS 125747]
IEEE Std 830-1998. *IEEE Recommended Practice for Software Requirements Specifications.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 242658.

[DIRS 164224]
IEEE Std 835-1994. 1994. *IEEE Standard Power Cable Ampacity Tables.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254237.

[DIRS 145722]
IEEE Std 946-1992. 1993. *IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 248438.

[DIRS 164270]
IEEE Std C37.110-1996. 1996. *IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254123.

[DIRS 164212]
IEEE Std C37.20.1™-2002. 2002. *IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254118.

[DIRS 169834]
IEEE Std C57.12.23™-2002. *IEEE Standard for Underground Type, Self-Cooled, Single-Phase, Distribution Transformers with Separable Insulated High-Voltage Connectors; High Voltage 25 000 V and Below; Low Voltage 600 V and Below; 167 kVA and Smaller.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254236.

[DIRS 173593]
IEEE Std C62.23-1995(R2001). 2001. *IEEE Application Guide for Surge Protection of Electric Generating Plants.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257259.

[DIRS 171932]
ISA-18.1-1979 (R2004). 2004. *Annunciator Sequences and Specification.* Research Triangle Park, North Carolina: Instrumentation, Systems, and Automation Society. TIC: 256621.

[DIRS 164263]
ISA-5.3-1983. 1983. *Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems*. Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254147.

[DIRS 164231]
ISA-MC96.1-1982. 2003. *Temperature Measurement Thermocouples*. Research Triangle Park, North Carolina: Instrumentation, Systems, and Automation Society. TIC: 254132.

[DIRS 167089]
ISA-RP16.1,2,3-1959. *Terminology, Dimensions and Safety Practices for Indicating Variable Area Meters (Rotameters), RP16.2 Glass Tube; RP16.2 Metal Tube; RP16.3 Extension-Type Glass Tube.* Research Triangle Park, North Carolina: Instrumentation Society of America. TIC: 255535.

[DIRS 167088]
ISA-RP16.5-1961. *Installation, Operation, and Maintenance Instructions for Glass Tube Variable Area Meters (Rotameters).* Research Triangle Park, North Carolina: Instrumentation Society of America. TIC: 255536.

[DIRS 167087]
ISA-RP16.6-1961. 1982. *Methods and Equipment for Calibration of Variable Area Meters (Rotameters).* Research Triangle Park, North Carolina: Instrumentation Society of America. TIC: 255537.

[DIRS 169812]
ISA-RP31.1-1977. *Specification, Installation, and Calibration of Turbine Flowmeters.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 256163.

[DIRS 164283]
ISA-S5.5-1985. 1986. *Graphic Symbols for Process Displays.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254080.

[DIRS 166931]
ISO/IEC 11172-1:1993/Cor.2:1999(E). 1999. *Information Technology — Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to About 1,5 Mbit/s – Part 1: Systems.* Genève, Switzerland: International Organization for Standardization. TIC: 254153.

[DIRS 167695]
ISO/IEC 11172-2:1993/Cor.3:2003(E). 2003. *Information Technology — Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to about 1,5 Mbit/s — Part 2: Video.* Geneva, Switzerland: International Organization for Standardization. TIC: 254153; 255769.

[DIRS 167696]
ISO/IEC 11172-3:1993/Cor. 1:1996(E). 1996. *Information Technology — Coding of Moving Pictures and Associated Audio for Digital Storage Media at Up to About 1,5 Mbit/s – Part 3: Audio.* Geneve, Switzerland: International Organization for Standardization. TIC: 254153.

[DIRS 166812]
ISO/IEC 13818-1:2000 (E). 2000. *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information: Systems.* Geneva, Switzerland: International Organization for Standardization. TIC: 254395.

[DIRS 166813]
ISO/IEC 13818-2:2000 (E). 2000. *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information: Video.* Geneva, Switzerland: International Organization for Standardization. TIC: 254947.

[DIRS 166814]
ISO/IEC 13818-3: 1998 (E). 1998. *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information: Part 3 --Audio.* 2nd Edition, Geneve, Switzerland: International Organization for Standardization. TIC: 254950.

[DIRS 166824]
ITU-T Rec. G.703 (11-2001). 2002. *Physical/Electrical Characteristics of Hierarchical Digital Interfaces, Series G: Transmission Systems and Media, Digital Systems and Networks, Digital Terminal Equipments – General.* Geneva, Switzerland: International Telecommunication Union. TIC: 255470.

[DIRS 166880]
ITU-T Rec. G.711. 1993. *General Aspects of Digital Transmission Systems, Terminal Equipments, Pulse Code Modulation (PCM) of Voice Frequencies.* Geneva, Switzerland: International Telecommunication Union. TIC: 255173.

[DIRS 166882]
ITU-T Rec. G.729. 1996. *General Aspects of Digital Transmission Systems, Coding of Speech at 8 kbit/s Using Conjugate-Structure Algebraic-Code-Excited Linear-Prediction (CS-ACELP).* Geneva, Switzerland: International Telecommunication Union. TIC: 255200.

[DIRS 166819]
Kent, S. and Atkinson, R. 1998. *Security Architecture for the Internet Protocol.* RFC 2401. [Reston, Virginia]: Internet Society. TIC: 255476.

[DIRS 166847]
Lee, A. 1999. *Guideline for Implementing Cryptography in the Federal Government.* NIST Special Publication 800-21. Gaithersburg, Maryland: U.S. Department of Commerce, National Institute of Standards and Technology. ACC: MOL.20040305.0180.

LP-3.25Q-BSC, Rev 1, ICN 6. *Design Criteria.* Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20050425.0002.

[DIRS 132324]
McConnell, J.W.; Ayers, A.L. Jr.; and Tyacke, M.J. 1996. *Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety.* NUREG/CR-6407. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 132324.

[DIRS 110957]
McConnell, K.I. and Lee, M.P. 1994. *Staff Technical Position on Consideration of Fault Displacement Hazards in Geologic Repository Design.* NUREG-1494. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 212360.

[DIRS 105205]
McConnell, K.I.; Blackford, M.E.; and Ibrahim, A.B. 1992. *Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geological Repository.* NUREG-1451. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 204829.

[DIRS 170418]
MIL-STD-1472F, Notice 1. 2003. *Department of Defense Design Criteria Standard, Human Engineering.* Washington, D.C.: U.S. Department of Defense. TIC: 256247.

[DIRS 164146]
Moy, J. 1994. *OSPF Version 2*. RFC 1583. [Reston, Virginia: Internet Society]. TIC: 254631.

[DIRS 104039]
NAC (Nevada Administrative Code) 444. Sanitation. Readily available.

[DIRS 166414]
NAC (Nevada Administrative Code) 444A. Programs for Recycling. Readily available.

[DIRS 104040]
NAC (Nevada Administrative Code) 445A. Water Controls. Readily available.

[DIRS 104041]
NAC (Nevada Administrative Code) 445B. Air Controls. Readily available.

[DIRS 172702]
NAC (Nevada Administrative Code) 519A. Regulation of Land Subject to Mining Operations or Exploration Projects. Readily available.

[DIRS 165132]
NACE Standard RP0169-2002. *Standard Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems*. Houston, Texas: National Association of Corrosion Engineers. TIC: 254895.

[DIRS 173097]
NACE Standard RP0572-2001. 2001. *Standard Recommended Practice, Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds*. Houston, Texas: National Association of Corrosion Engineers. TIC: 257208.

[DIRS 159251]
National Technology Transfer and Advancement Act of 1995. Public Law No. 104-113, 110 Stat. 775. Readily available.

[DIRS 164223]
NEMA ICS 1-2000. 2001. *Industrial Control and Systems General Requirements*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254262.

[DIRS 164222]
NEMA ICS 6-1993 (R 2001). 2001. *Industrial Control and Systems: Enclosures*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254261.

[DIRS 164241]
NEMA ICS 7-2000. 2001. *Industrial Control and Systems: Adjustable-Speed Drives*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254073.

[DIRS 153084]
NEMA MG 1-1998, Rev. 1. 2000. *Motors and Generators*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 249172.

[DIRS 153086]
NEMA MG 10-1994. *Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors*. Washington, D.C.: National Electrical Manufacturers Association. TIC: 249173.

[DIRS 164202]
NEMA MG 11-1977 (R1997, R2001). 2001. *Energy Management Guide for Selection and Use of Single-Phase Motors*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254110.

[DIRS 161825]
NEMA PB 1-1990. *Panelboards*. Standards Publication No. PB 1. Washington, D.C.: National Electrical Manufacturers Association. TIC: 3617.

[DIRS 169833]
NEMA PB 2-2001. 2002. *Deadfront Distribution Switchboards*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255931.

[DIRS 169799]
NEMA PE 1-2003. 2003. *Uninterruptible Power Systems (UPS) - Specification and Performance Verification*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255932.

[DIRS 169323]
NEMA SG 5-1995. 1996. *Power Switchgear Assemblies*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255921.

[DIRS 169324]
NEMA SG 6-2000. 2001. *Power Switching Equipment*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255922.

[DIRS 164297]
NEMA TR 1-1993 (R 2000). 2002. *Transformers, Regulators and Reactors*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254072.

[DIRS 173599]
NEMA WC 2-1991. 2001. *Steel Armor and Associated Coverings for Impregnated Paper Insulated Cables*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255992.

[DIRS 173600]
NEMA WC 50-1976 (R 1982, 1988). 1989. *Ampacities, Including Effect of Shield Losses for Single-Conductor Solid-Dielectric Power Cable, 15kV through 69kV (Copper and Aluminum Conductors)*. Washington, D.C.: National Electrical Manufacturers Association. TIC: 255993.

[DIRS 173601]
NEMA WC 51-2003. 2004. *Ampacities of Cables Installed in Cable Trays*. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255994.

[DIRS 173602]
NEMA WC 57-1995, Rev. 2. 1998. *Standard for Control Cables.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255995.

[DIRS 158602]
NEMA WC 58-1997. 2000. *Portable and Power Feeder Cables for Use in Mines and Similar Applications.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 252692.

[DIRS 173594]
NEMA WC 7-1988. 1990. *Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.* Washington, D.C.: National Electrical Manufacturers Association. TIC: 232408.

[DIRS 173603]
NEMA WC 70/ICEA S-95-658-1999. 1999. *Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.* South Yarmouth, Massachusetts: Insulated Cable Engineers Association. TIC: 255996.

[DIRS 173604]
NEMA WC 71-1999. 1999. *Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255997.

[DIRS 173605]
NEMA WC 74-2000. 2002. *5-46kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255998.

[DIRS 158601]
NEMA WC 8-1988. 1996. *Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 252691.

[DIRS 173507]
NFPA 1. 2003. *Uniform Fire Code (includes Extract Update 1-03-2).* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257235.

[DIRS 160950]
NFPA 10. 2002. *Standard for Portable Fire Extinguishers.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253678.

[DIRS 165076]
NFPA 101®. 2003. *Life Safety Code®.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 254861.

[DIRS 173508]
NFPA 11. 2005. *Standard for Low-, Medium-, and High-Expansion Foam.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257236.

[DIRS 173511]
NFPA 110. 2005. *Standard for Emergency and Standby Power Systems.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257240.

[DIRS 160936]
NFPA 1144. 2002. *Standard for Protection of Life and Property from Wildfire.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253676.

[DIRS 160921]
NFPA 13. 2002. *Standard for the Installation of Sprinkler Systems.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253657.

[DIRS 165074]
NFPA 14. 2003. *Standard for the Installation of Standpipe and Hose Systems.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 254859.

[DIRS 159163]
NFPA 15. 2001. *Standard for Water Spray Fixed Systems for Fire Protection.* 2001 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 252914.

[DIRS 173509]
NFPA 16. 2003. *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257237.

[DIRS 160951]
NFPA 17. 2002. *Standard for Dry Chemical Extinguishing Systems.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253680.

[DIRS 166981]
NFPA 1963. 2003. *Standard for Fire Hose Connections.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255486.

[DIRS 165722]
NFPA 20. 2003. *Standard for the Installation of Stationary Pumps for Fire Protection.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255069.

[DIRS 154764]
NFPA 2001. 2000. *Standard for Clean Agent Fire Extinguishing Systems.* 2000 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 249694.

[DIRS 173512]
NFPA 214. 2005. *Standard on Water-Cooling Towers.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257241.

[DIRS 165075]
NFPA 22. 2003. *Standard for Water Tanks for Private Fire Protection.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 254860.

[DIRS 160949]
NFPA 221. 2000. *Standard for Fire Walls and Fire Barrier Walls.* 2000 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253677.

[DIRS 160922]
NFPA 24. 2002. *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253658.

[DIRS 160952]
NFPA 25. 2002. *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253684.

[DIRS 173417]
NFPA 256. 2003. *Standard Methods of Fire Tests of Roof Coverings.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257159.

[DIRS 173510]
NFPA 30. 2003. *Flammable and Combustible Liquids Code.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257239.

[DIRS 166906]
NFPA 31. 2001. *Standard for the Installation of Oil-Burning Equipment.* 2001 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255440.

[DIRS 170661]
NFPA 418. 2001. *Standard for Heliports.* 2001 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 256275.

[DIRS 173514]
NFPA 497. 2004. *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257243.

[DIRS 173515]
NFPA 502. 2004. *Standard for Road Tunnels, Bridges, and Other Limited Access Highways.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257244.

[DIRS 166980]
NFPA 51B. 2003. *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255487.

[DIRS 170148]
NFPA 55. 2003. *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 256195.

[DIRS 159165]
NFPA 68. 2002. *Guide for Venting of Deflagrations.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 252925.

[DIRS 160953]
NFPA 69. 2002. *Standard on Explosion Prevention Systems.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253685.

[DIRS 172711]
NFPA 70. 2004. *National Electrical Code®.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 256883.

[DIRS 160954]
NFPA 72. 2002. *National Fire Alarm Code.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253686.

[DIRS 167085]
NFPA 75. 2003. *Standard for the Protection of Information Technology Equipment.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255522.

[DIRS 173516]
NFPA 750. 2003. *Standard on Water Mist Fire Protection Systems.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257245.

[DIRS 173517]
NFPA 780. 2004. *Standard for the Installation of Lightning Protection Systems.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257246.

[DIRS 161824]
NFPA 80. 1999. *Standard for Fire Doors and Fire Windows.* 1999 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 249883.

[DIRS 165077]
NFPA 801. 2003. *Standard for Fire Protection for Facilities Handling Radioactive Materials.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 254811.

[DIRS 160934]
NFPA 80A. 2001. *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.* 2001 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253672.

[DIRS 160955]
NFPA 90A. 2002. *Standard for the Installation of Air-Conditioning and Ventilating Systems.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253687.

[DIRS 166885]
Nichols, K.; Blake, S.; Baker, F.; and Black, D. 1998. *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers.* RFC 2474. [Reston, Virginia]: Internet Society. TIC: 255485.

[DIRS 147940]
NIOSH (National Institute for Occupational Safety and Health) 1996. "Silica, Crystalline (as Respirable Dust)." [Washington, D.C.]: National Institute for Occupational Safety and Health. Accessed April 8, 1999. TIC: 243424. http://www.cdc.gov/niosh/idlh/14808607.html

[DIRS 103347]
NRC (U.S. Nuclear Regulatory Commission) 1979. *Single-Failure-Proof Cranes for Nuclear Power Plants.* NUREG-0554. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 232978.

[DIRS 104939]
NRC (U.S. Nuclear Regulatory Commission) 1980. *Control of Heavy Loads at Nuclear Power Plants.* NUREG-0612. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 209017.

[DIRS 103124]
NRC (U.S. Nuclear Regulatory Commission) 1987. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants.* NUREG-0800. LWR Edition. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 203894.

[DIRS 165110]
NRC (U.S. Nuclear Regulatory Commission) [1989]. "Seismic Design Parameters." Revision 2 of Section 3.7.1 of *Standard Review Plan [for the Review of Safety Analysis Reports for Nuclear Power Plants].* NUREG-0800. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20030910.0150.

[DIRS 165112]
NRC (U.S. Nuclear Regulatory Commission) 1989. "Seismic Subsystem Analysis." Revision 2 of Section 3.7.3 of *Standard Review Plan [for the Review of Safety Analysis Reports for Nuclear Power Plants].* NUREG-0800. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20030910.0152.

[DIRS 165111]
NRC (U.S. Nuclear Regulatory Commission) [1989]. "Seismic System Analysis." Revision 2 of Section 3.7.2 of *Standard Review Plan [for the Review of Safety Analysis Reports for Nuclear Power Plants].* NUREG-0800. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20030910.0151.

[DIRS 159029]
NRC (U.S. Nuclear Regulatory Commission) 1995. *Standard Format and Content Acceptance Criteria for the Material Control and Accounting (MC&A) Reform Amendment.* NUREG-1280, Rev. 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040401.0108.

[DIRS 101903]
NRC (U.S. Nuclear Regulatory Commission) 1997. *Standard Review Plan for Dry Cask Storage Systems.* NUREG-1536. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010724.0307.

[DIRS 149756]
NRC (U.S. Nuclear Regulatory Commission) 2000. *Standard Review Plan for Spent Fuel Dry Storage Facilities.* NUREG-1567. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 247929.

[DIRS 154000]
NRC (U.S. Nuclear Regulatory Commission) 2000. *Standard Review Plan for Transportation Packages for Spent Nuclear Fuel.* NUREG-1617. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 249470.

[DIRS 160595]
NRC (U.S. Nuclear Regulatory Commission) 2001. "Interim Staff Guidance - 6. Establishing Minimum Initial Enrichment for the Bounding Design Basis Fuel Assembly(s)." ISG-6. Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed July 27, 2001. TIC: 253434. http:/www.nrc.gov/OPA/reports/isg6.htm

[DIRS 159567]
NRC (U.S. Nuclear Regulatory Commission) 2002. *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility.* NUREG-1520. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 253141.

[DIRS 170332]
NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 11, Revision 3. Cladding Considerations for the Transportation and Storage of Spent Fuel.* ISG-11, Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040721.0065.

[[DIRS 163274]
NRC (U.S. Nuclear Regulatory Commission) 2003. *Yucca Mountain Review Plan, Final Report.* NUREG-1804, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 254568.

[DIRS 101681]
Nuclear Waste Policy Act of 1982. 42 U.S.C. 10101 et seq. Readily available.

[DIRS 170780]
O'Hara, J.M.; Brown, W.S.; Lewis, P.M.; and Persensky, J.J. 2002. *Human-System Interface Design Review Guidelines.* NUREG-0700, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research. ACC: MOL.20040816.0036.

[DIRS 159250]
OMB Circular No. A-119. 1998. *Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities.* [Washington, D.C.]: Office of Management and Budget. Readily available.

[DIRS 170595]
OSHA (Occupational Safety & Health Administration) [1999]. "Legionnaires' Disease" Section III: Chapter 7 of OSHA Technical Manual Washington, D.C.: Occupational Safety & Health Administration. Accessed July 20, 2004. ACC: MOL.20040720.0040.

[DIRS 166817]
Perkins, C. 2002. *IP Mobility Support for IPv4.* RFC 3344. [Reston, Virginia]: Internet Society. TIC: 254957.

[DIRS 103930]
Pollution Prevention Act of 1990. 42 U.S.C. 13101 et seq. Readily available.

[DIRS 167059]
Postel, J., ed. 1981. *Internet Protocol, DARPA Internet Program Protocol Specification.* RFC 791. Marina del Rey, California: University of Southern California, Information Sciences Institute. TIC: 255521.

[DIRS 167060]
Postel, J., ed. 1981. *Transmission Control Protocol, DARPA Internet Program Protocol Specification.* RFC 793. Marina del Ray, California: University of Southern California, Information Sciences Institute. TIC: 255520.

[DIRS 103693]
Ramsdell, J.V. and Andrews, G.L. 1986. *Tornado Climatology of the Contiguous United States.* NUREG/CR-4461. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010727.0159.

[DIRS 165131]
Rea, M.S., ed. 2000. *IESNA Lighting Handbook, Reference & Application.* 9th Edition. New York, New York: Illuminating Engineering Society of North America. TIC: 254894.

[DIRS 103170]
Regulatory Guide 1.12, Rev. 02. 1997. *Nuclear Power Plant Instrumentation for Earthquakes.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 105991]
Regulatory Guide 1.21, Rev. 1. 1974. *Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 223043.

[DIRS 103640]
Regulatory Guide 1.23, Rev. 0. 1972. *Onsite Meteorological Programs.* Washington, D.C.: U.S. Atomic Energy Commission. Readily available.

[DIRS 107691]
Regulatory Guide 1.25, Rev. 0. 1972. *Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors*. Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103311]
Regulatory Guide 1.29, Rev. 3. 1978. *Seismic Design Classification.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 226259.

[DIRS 171692]
Regulatory Guide 1.52, Rev. 3. 2001. *Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 171817]
Regulatory Guide 1.53, Rev. 2. 2003. *Application of the Single-Failure Criterion to Safety Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 131488]
Regulatory Guide 1.59, Rev. 2. 1977. *Design Basis Floods for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 149473]
Regulatory Guide 1.61. 1973. *Damping Values for Seismic Design of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103116]
Regulatory Guide 1.62, Rev. 0. 1973. *Manual Initiation of Protective Actions.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 106281]
Regulatory Guide 1.76, Rev. 0. 1974. *Design Basis Tornado for Nuclear Power Plants.* Washington, D.C.: U.S. Atomic Energy Commission. TIC: 2717.

[DIRS 102609]
Regulatory Guide 1.89, Rev. 1. 1984. *Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103638]
Regulatory Guide 1.91, Rev. 1. 1978. *Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 151403]
Regulatory Guide 1.92, Rev. 1. 1976. *Combining Modal Responses and Spatial Components in Seismic Response Analysis.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 2775.

[DIRS 110810]
Regulatory Guide 1.100, Rev. 2. 1988. *Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 117499]
Regulatory Guide 1.102, Rev. 1. 1976. *Flood Protection for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 165738]
Regulatory Guide 1.105, Rev. 3. 1999. *Setpoints for Safety-Related Instrumentation.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 100067]
Regulatory Guide 1.109, Rev. 1. 1977. *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: NNA.19870806.0032.

[DIRS 144751]
Regulatory Guide 1.117, Rev. 1. 1978. *Tornado Design Classification.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 151404]
Regulatory Guide 1.122, Rev. 1. 1978. *Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components.* [Washington, D.C.]: U.S. Nuclear Regulatory Commission. TIC: 2787.

[DIRS 158855]
Regulatory Guide 1.140, Rev. 2. 2001. *Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 157566]
Regulatory Guide 1.143, Rev. 2. 2001. *Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103651]
Regulatory Guide 1.145, Rev. 1. 1982. *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103164]
Regulatory Guide 1.152, Rev. 1. 1996. *Criteria for Digital Computers in Safety Systems of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103165]
Regulatory Guide 1.153, Rev. 1. 1996. *Criteria for Safety Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 119139]
Regulatory Guide 1.165. 1997. *Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 168888]
Regulatory Guide 1.168, Rev. 1. 2004. *Verification, Validation, Reviews, and Audits for Digital Computer Software Used in Safety Systems of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103176]
Regulatory Guide 1.169, Rev. 0. 1997. *Configuration Management Plans for Digital Computer Software Used in Safety Systems of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103179]
Regulatory Guide 1.170, Rev. 0. 1997. *Software Test Documentation for Digital Computer Software Used in Safety Systems of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103181]
Regulatory Guide 1.171, Rev. 0. 1997. *Software Unit Testing for Digital Computer Software Used in Safety Systems of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103182]
Regulatory Guide 1.172, Rev. 0. 1997. *Software Requirements Specifications for Digital Computer Software Used in Safety Systems of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103183]
Regulatory Guide 1.173, Rev. 0. 1997. *Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 171818]
Regulatory Guide 1.180, Rev. 1. 2003. *Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 155040]
Regulatory Guide 1.189. 2001. *Fire Protection for Operating Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[[DIRS 158804]
Regulatory Guide 3.18, Rev. 0. 1974. *Confinement Barriers and Systems for Fuel Reprocessing Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238370.

[DIRS 171701]
Regulatory Guide 3.20, Rev, 0. 1974. *Process Offgas Systems for Fuel Reprocessing Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238368.

[DIRS 103310]
Regulatory Guide 3.32, Rev. 0. 1975. *General Design Guide for Ventilation Systems for Fuel Reprocessing Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103299]
Regulatory Guide 3.71. 1998. *Nuclear Criticality Safety Standards for Fuels and Material Facilities.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 172763]
Regulatory Guide 3.73. 2003. Site Evaluations and Design Earthquake Ground Motion for Dry Cask Independent Spent Fuel Storage and Monitored Retrievable Storage Installations. Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 105993]
Regulatory Guide 4.1, Rev. 1. 1975. *Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 3698.

[DIRS 103534]
Regulatory Guide 5.7, Rev. 1. 1980. *Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 158856]
Regulatory Guide 5.12. 1973. *General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103532]
Regulatory Guide 5.26, Rev. 1. 1975. *Selection of Material Balance Areas and Item Control Areas.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235878.

[DIRS 165827]
Regulatory Guide 5.27. 1974. *Special Nuclear Material Doorway Monitors.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 158857]
Regulatory Guide 5.44, Rev. 03. 1997. *Perimeter Intrusion Alarm Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 165832]
Regulatory Guide 5.49, Rev. 0. 1975. *Internal Transfers of Special Nuclear Material.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235798.

[DIRS 167366]
Regulatory Guide 5.52, Rev. 3. 1994. *Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material at Fixed Sites (Other than Nuclear Power Plants).* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 227031.

[DIRS 165838]
Regulatory Guide 5.61, Rev. 0. 1980. *Intent and Scope of the Physical Protection Upgrade Rule Requirements for Fixed Sites.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235795.

[DIRS 165839]
Regulatory Guide 5.62, Rev. 1. 1987. *Reporting of Safeguards Events.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235794.

[DIRS 158858]
Regulatory Guide 5.65. 1986. *Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 167365]
Regulatory Guide 5.68, Rev. 0. 1994. *Protection Against Malevolent Use of Vehicles at Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235875.

[DIRS 106074]
Regulatory Guide 8.5, Rev. 1. 1981. *Criticality and Other Interior Evacuation Signals.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238353.

[DIRS 103312]
Regulatory Guide 8.8, Rev. 3. 1978. *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be as Low as is Reasonably Achievable.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 103368]
Regulatory Guide 8.10, Rev. 1-R. 1977. *Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as is Reasonably Achievable.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 148894]
Regulatory Guide 8.19, Rev. 1. 1979. *Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants Design Stage Man-Rem Estimates.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: NNA.19870728.0014.

[DIRS 106172]
Regulatory Guide 8.25, Rev.1. 1992. *Air Sampling in the Workplace.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238394.

[DIRS 103658]
Regulatory Guide 8.34, Rev. 0. 1992. *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available.

[DIRS 106181]
Regulatory Guide 8.38, Rev. 0. 1993. *Control of Access to High and Very High Radiation Areas in Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238387.

[DIRS 164148]
Rekhter, Y.; Moskowitz, B.; Karrenberg, D.; de Groot, G.J.; and Lear, E. 1996. *Address Allocation for Private Internets.* RFC 1918. [Reston, Virginia: Internet Society]. TIC: 254632.

[DIRS 103936]
Resource Conservation and Recovery Act of 1976. 42 U.S.C. 6901 et seq. Readily available.

[DIRS 166838]
Rose, M. and McCloghrie, K. 1990. *Structure and Identification of Management Information for TCP/IP-Based Internets.* RFC 1155. [Reston, Virginia]: Internet Society. TIC: 255475.

[DIRS 166815]
Rosenberg, J.; Schulzrinne, H.; Camarillo, G.; Johnston, A.; Peterson, J.; Sparks, R.; Handley, M.; and Schooler, E. 2002. *SIP: Session Initiation Protocol.* RFC 3261. [Reston, Virginia]: Internet Society. TIC: 254958.

[DIRS 171652]
SAE J1078 Reaffirmed APR94. 1994. *A Recommended Method of Analytically Determining the Competence of Hydraulic Telescopic Cantilevered Crane Booms.* Warrendale, Pennsylvania: Society of Automotive Engineers. TIC: 253027.

[DIRS 103937]
Safe Drinking Water Act. 42 U.S.C. 300f et seq. Readily available.

[DIRS 161833]
SMACNA (Sheet Metal and Air Conditioning Contractors National Association) 1985. *HVAC Air Duct Leakage Test Manual.* 1st Edition. Chantilly, Virginia: Sheet Metal and Air Conditioning Contractors National Association. TIC: 232334.

[DIRS 158927]
SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) 1995. *HVAC Duct Construction Standards Metal and Flexible.* 2nd Edition. Chantilly, Virginia: Sheet Metal and Air Conditioning Contractor National Association. TIC: 232331.

[DIRS 167121]
SMPTE 170M-1999. *SMPTE Standard for Television — Composite Analog Video Signal — NTSC for Studio Applications.* White Plains, New York: Society of Motion Picture and Television Engineers. TIC: 255539.

[DIRS 164162]
T1.105-2001. 2002. *Synchronous Optical Network (SONET) -- Basic Description Including Multiplex Structure, Rates, and Formats, Including Supplement T1.105a-2002.* Washington, D.C.: Alliance for Telecommunications Industry Solutions. TIC: 254657.

[DIRS 164215]
TEMA (Tubular Exchanger Manufacturers Association) 1999. *Standards of the Tubular Exchanger Manufacturers Association.* 8th Edition. Tarrytown, New York: Tubular Exchanger Manufacturers Association. TIC: 254228.

[DIRS 166835]
TIA (Telecommunication Industry Association) [2003]. *Project 25--The TIA-Published 102-Series Documents.* [Arlington, Virginia]: Telecommunications Industry Association. TIC: 255898.

[DIRS 167311]
UL (Underwriters Laboratories) 2003. *Fire Resistance Directory 2003, with Hourly Ratings for Joint Systems, Through-Penetration Firestop Systems and Electrical Circuit Protective Systems and Duct Assemblies.* Volume 2A. Northbrook, Illinois: Underwriters Laboratories. TIC: 254191.

[DIRS 167312]
UL (Underwriters Laboratories) 2003. *Fire Resistance Directory 2003, with Hourly Ratings for Joint Systems, Through-Penetration Firestop Systems and Electrical Circuit Protective Systems and Duct Assemblies.* Volume 2B. Northbrook, Illinois: Underwriters Laboratories. TIC: 254191.

[DIRS 167310]
UL (Underwriters Laboratories) 2003. *Fire Resistance Directory 2003.* Volume 1. Northbrook, Illinois: Underwriters Laboratories. TIC: 254191.

[DIRS 164301]
UL (Underwriters Laboratories) 2003. *Fire Resistance Directory 2003.* Volume 3. Northbook, Illinois: Underwriters Laboratories. TIC: 254191.

[DIRS 169577]
UL 1581. 2003. *Reference Standard for Electrical Wires, Cables, and Flexible Cords.* Northbrook, Illinois: Underwriters Laboratories. TIC: 256108.

[DIRS 158862]
UL 437. 2000. *Standard for Key Locks.* Northbrook, Illinois: Underwriters Laboratories. TIC: 252749.

[DIRS 169802]
UL 508. 2003. *Industrial Control Equipment.* 17th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 256206.

[DIRS 169816]
UL 586. 2000. *High-Efficiency, Particulate, Air Filter Units.* 8th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 256166.

[DIRS 169801]
UL 67. 2003. *Panelboards.* 11th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 256024.

[DIRS 158864]
UL 768. 1999. *Standard for Combination Locks.* Northbrook, Illinois: Underwriters Laboratories. TIC: 252751.

[DIRS 173419]
UL 790. 2004. *Standard for Standard Test Methods for Fire Tests of Roof Coverings.* 8th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 257161.

[DIRS 166725]
UL 900. 1999. *Air Filter Units.* 6th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 255495.

[DIRS 166768]
UL 96A. 2001. *Installation Requirements for Lightning Protection Systems.* 11th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 255223.

[DIRS 166979]
Underwriters Laboratories. 2003. *Fire Protection Equipment Directory 2003.* Northbrook, Illinois: Underwriters Laboratories. TIC: 255496.

[DIRS 164302]
Urban Water Resources Research Council, American Society of Civil Engineers. 1992. *Design and Construction of Urban Stormwater Management Systems.* ASCE Manuals and Reports on Engineering Practice No. 77. Reston, Virginia: American Society of Civil Engineers. TIC: 254193.

7.3 SOURCE DATA, LISTED BY DATA TRACKING NUMBER

[DIRS 166735]
GS030808312231.004. Moisture Monitoring in the Exploratory Studies Facility (ESF) from August 2000 to July 2002. Submittal date: 09/26/2003.

[DIRS 148735]
MO0003YMP99042.001. Nevada Test Site (NTS) Infrastructure Near to the Preclosure Controlled Area. Submittal date: 03/17/2000.

[DIRS 166731]
MO0206SEPQ1998.001. Meteorological Monitoring Data for 1998. Submittal date: 06/26/2002.

[DIRS 166730]
MO0209SEPQ2000.001. Meteorological Monitoring Data for 2000. Submittal date: 09/09/2002.

[DIRS 161983]
MO0211HISTMPEX.000. Summary of Ambient Temperature Extremes at Amargosa Farms, Beatty, and Desert Rock WSMO, Nevada. Submittal date: 11/13/2002.

[DIRS 166165]
MO0302METMON99.001. Meteorological Monitoring Data for 1999, Sites 1-9, Hourly and Ten Minute. Submittal date: 02/13/2003.

[DIRS 162490]
MO0303SGPM9502.000. Storage Gauge Precipitation Measurements, Yucca Mountain 1995-2002. Submittal date: 03/11/2003.

[DIRS 166164]
MO0305SEP01MET.002. Meteorological Monitoring Data for 2001. Submittal date: 05/21/2003.

[DIRS 166163]
MO0305SEP02MET.002. Meteorological Monitoring Data for 2002. Submittal date: 05/21/2003.

[DIRS 165395]
MO0307MWDAC8MV.000. Analytical-La-Coarse-800M Ventilation. Submittal date: 07/15/2003.

[DIRS 169194]
MO0403SEPPRFQE.000. Hourly and Daily Precipitation Return Frequency Estimates at Yucca Mountain Meteorological Tower, Site 1. Submittal date: 03/17/2004.

[DIRS 169851]
MO0405SDSTPNTB.001. Seismic Design Spectra (5% Damped) and Time Histories for the Emplacement Level (Point B) at 10-3 Annual Exceedance Frequency. Submittal date: 05/03/2004.

[DIRS 170462]
MO0405SEPRHVMM.000. Mean Relative Humidity Values for Meteorological Monitoring Site 1 from 1998-2002. Submittal date: 05/25/2004.

[DIRS 169326]
MO0405XTMP9802.000. Extreme Temperature Values For Meteorlogical Monitoring Sites From 1998-2002. Submittal date: 05/10/2004.

[DIRS 170683]
MO0407SDARS104.001. Seismic Design Acceleration Response Spectra for the Repository Level at 5X10-4 Annual Exceedance Frequency. Submittal date: 07/14/2004.

[DIRS 170599]
MO0407TMHIS104.003. Acceleration, Velocity and Displacement Time Histories for the Emplacement Level (Point B) at 5X10-4 Annual Exceedance Frequency. Submittal date: 07/15/2004.

[DIRS 171885]
MO0409SEPNOAPD.000. NOAA Extreme Annual Precipitation Data. Submittal date: 09/30/2004.

[DIRS 172425]
MO0411SDSDE103.003. Seismic Design Spectra and Time Histories for the Surface Facilities Area (Point D/E) at 10-3 Annual Exceedance Frequency. Submittal date: 11/16/2004.

[DIRS 172426]
MO0411SDSTMHIS.006. Seismic Design Spectra and Time Histories for the Surface Facilities Area (Point D/E) at 5E-4 Annual Exceedance Frequency. Submittal date: 11/16/2004.

[DIRS 172427]
MO0411WHBDE104.003. Seismic Design Spectra and Time Histories for the Surface Facilities Area (Point D/E) at 10-4 Annual Exceedance Frequency. Submittal date: 11/16/2004.

[DIRS 173394]
MO0504DSRKSNOW.001. Climatological Snow Data For Desert Rock WSMO, Nevada, 01/01/1983 TO 02/28/2005. Submittal date: 04/07/2005.

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APPENDIX A

LIST OF REGULATORY GUIDANCE DOCUMENTS AND DOE ORDERS

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APPENDIX A

LIST OF REGULATORY GUIDANCE DOCUMENTS AND DOE ORDERS

A summary list of regulatory guidance documents and Yucca Mountain positions is presented in Table A-1. Where a regulatory guidance document refers to safety-related, replace with ITS or ITWI.

Table A-1. Summary List of Regulatory Guidance Documents and Yucca Mountain Project Positions

Document Number	Document Title	YMP Position		YMRP (NRC 2003 [DIRS 163274])
		Conform	Conform with Exception	
ISG-6	Interim Staff Guidance - 6. Establishing Minimum Initial Enrichment for the Bounding Design Basis Fuel Assembly(s)	X		
ISG-11, Rev. 3	Interim Staff Guidance - 11, Revision 3. Cladding Considerations for the Transportation and Storage of Spent Fuel		X	
NUREG-0554	Single-Failure-Proof Cranes for Nuclear Power Plants		X	
NUREG-0612	Control of Heavy Loads at Nuclear Power Plants		X	
NUREG-0700, Rev. 2	Human-System Interface Design Review Guidelines		X	
NUREG-0800	Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants		X	
NUREG-1065, Rev 2	Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities		X	
NUREG-1280, Rev. 1	Standard Format and Content Acceptance Criteria for the Material Control and Accounting (MC&A) Reform Amendment		X	
NUREG-1451	Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository		X	
NUREG-1494	Staff Technical Position on Consideration of Fault Displacement Hazards and Seismic Hazards at a Geological Repository		X	
NUREG-1520	Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility		X	X
NUREG-1536	Standard Review Plan for Dry Cask Storage Systems		X	
NUREG-1567	Standard Review Plan for Spent Fuel Dry Storage Facilities		X	
NUREG-1617	Standard Review Plan for Transportation Packages for Spent Nuclear Fuel		X	
NUREG-1804, Rev. 2	Yucca Mountain Review Plan, Final Report.	X		X
NUREG/CR-6407	Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety	X		
Reg Guide 1.12, Rev. 2	Nuclear Power Plant Instrumentation for Earthquakes		X	

Table A-1. Summary List of Regulatory Guidance Documents and Yucca Mountain Project Positions (Continued)

Document Number	Document Title	YMP Position: Conform	YMP Position: Conform with Exception	YMRP (NRC 2003 [DIRS 163274])
Reg Guide 1.21, Rev. 1	Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light Water Cooled Nuclear Power Plants		X	
Reg Guide 1.23, Rev. 0	Onsite Meteorological Programs		X	
Reg Guide 1.25, Rev. 0	Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors		X	
Reg Guide 1.52, Rev 3	Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants		X	
Reg Guide 1.53, Rev. 2	Application of the Single-Failure Criterion to Safety Systems		X	
Reg Guide 1.59, Rev. 2	Design Basis Floods for Nuclear Power Plants		X	
Reg Guide 1.61, Rev. 0	Damping Values for Seismic Design of Nuclear Power Plants	X		
Reg Guide 1.62, Rev. 0	Manual Initiation of Protective Actions	X		
Reg Guide 1.76, Rev. 0	Design Basis Tornado for Nuclear Power Plants		X	
Reg Guide 1.89, Rev. 1	Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants		X	
Reg Guide 1.91, Rev. 1	Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants	X		
Reg Guide 1.92, Rev. 1	Combining Modal Responses and Spatial Components in Seismic Response Analysis	X		
Reg Guide 1.100, Rev. 2	Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants	X		
Reg Guide 1.102, Rev. 1	Flood Protection for Nuclear Power Plants		X	
Reg Guide 1.105, Rev. 3	Setpoints for Safety-Related Instrumentation	X		
Reg Guide 1.109, Rev. 1	Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I		X	X
Reg Guide 1.117, Rev. 1	Tornado Design Classification		X	
Reg Guide 1.122, Rev. 1	Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components	X		

Table A-1. Summary List of Regulatory Guidance Documents and Yucca Mountain Project Positions (Continued)

Document Number	Document Title	YMP Position: Conform	YMP Position: Conform with Exception	YMRP (NRC 2003 [DIRS 163274])
Reg Guide 1.140, Rev. 2	Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants		X	
Reg Guide 1.143, Rev. 2	Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light Water Cooled Nuclear Power Plants	X		
Reg Guide 1.145, Rev. 1	Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants	X		X
Reg Guide 1.152, Rev. 1	Criteria for Digital Computers in Safety Systems of Nuclear Power Plants		X	
Reg Guide 1.153, Rev. 1	Criteria for Safety Systems		X	
Reg Guide 1.165, Rev. 0	Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion		X	
Reg Guide 1.168, Rev. 1	Verification, Validation, Reviews, and Audits for Digital Computer Software Used in Safety Systems of Nuclear Power Plants	X		
Reg Guide 1.169, Rev. 0	Configuration Management Plans for Digital Computer Software Used in Safety Systems of Nuclear Power Plants		X	
Reg Guide 1.170, Rev. 0	Software Test Documentation for Digital Computer Software Used in Safety Systems of Nuclear Power Plants		X	
Reg Guide 1.171, Rev. 0	Software Unit Testing for Digital Computer Software Used in Safety Systems of Nuclear Power Plants	X		
Reg Guide 1.172, Rev. 0	Software Requirements Specifications for Digital Computer Software Used in Safety Systems of Nuclear Power Plants		X	
Reg Guide 1.173, Rev. 0	Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems of Nuclear Power Plants		X	
Reg Guide 1.180, Rev. 1	Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems	X		
Reg Guide 1.189, Rev. 0	Fire Protection for Operating Nuclear Power Plants		X	
Reg Guide 3.18, Rev. 0	Confinement Barriers and Systems for Fuel Reprocessing Plants		X	
Reg Guide 3.20, Rev. 0	Process Offgas Systems for Fuel Reprocessing Plants	X		
Reg Guide 3.32, Rev. 0	General Design Guide for Ventilation Systems for Fuel Reprocessing Plants		X	
Reg Guide 3.71, Rev. 0	Nuclear Criticality Safety Standards for Fuels and Material Facilities		X	X
Reg Guide 3.73, Rev. 0	Site Evaluations and Design Earthquake Ground Motion for Dry Cask Independent Spent Fuel Storage and Monitored Retrievable Storage Installations		X	

Table A-1. Summary List of Regulatory Guidance Documents and Yucca Mountain Project Positions (Continued)

Document Number	Document Title	YMP Position		YMRP (NRC 2003 [DIRS 163274])
		Conform	Conform with Exception	
Reg Guide 4.1, Rev. 1	Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants		X	X
Reg Guide 5.7, Rev. 1	Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas	X		
Reg Guide 5.12, Rev. 0	General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials	X		X
Reg Guide 5.26, Rev. 1	Selection of Material Balance Areas and Item Control Areas		X	
Reg Guide 5.27, Rev. 0	Special Nuclear Material Doorway Monitors		X	
Reg Guide 5.44, Rev. 3	Perimeter Intrusion Alarm Systems	X		X
Reg Guide 5.49, Rev. 0	Internal Transfers of Special Nuclear Material		X	
Reg Guide 5.52, Rev. 3	Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material at Fixed Sites (Other than Nuclear Power Plants)		X	
Reg Guide 5.61, Rev. 0	Intent and Scope of the Physical Protection Upgrade Rule Requirements for Fixed Sites	X		
Reg Guide 5.62, Rev. 1	Reporting of Safeguards Events	X		
Reg Guide 5.65, Rev. 0	Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls	X		
Reg Guide 5.68, Rev. 0	Protection Against Malevolent Use of Vehicles at Nuclear Power Plants	X		
Reg Guide 8.05, Rev. 1	Criticality and Other Interior Evacuation Signals	X		X
Reg Guide 8.8, Rev. 3	Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be As Low As Is Reasonably Achievable	X		X
Reg Guide 8.10, Rev. 1-R	Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable	X		X
Reg Guide 8.19, Rev. 1	Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants Design Stage Man-Rem Estimates		X	
Reg Guide 8.25, Rev. 1	Air Sampling in the Workplace	X		
Reg Guide 8.34, Rev. 0	Monitoring Criteria and Methods to Calculate Occupational Radiation Doses	X		
Reg Guide 8.38, Rev. 0	Control of Access to High and Very High Radiation Areas of Nuclear Plants	X		X

Regulatory guidance documents and Yucca Mountain positions are as follows:

Regulatory Guidance Document Number: ISG-6. [DIRS 160595]

Regulatory Guidance Title:

INTERIM STAFF GUIDANCE - 6. ESTABLISHING MINIMUM INITIAL ENRICHMENT FOR THE BOUNDING DESIGN BASIS FUEL ASSEMBLY(S).

Regulatory Position:

The Standard Review Plan, NUREG-1536, Chapter 5, Section V, 2, recommends that "the applicant calculate the source term on the basis of the fuel that will actually provide the bounding source term," and states that the applicant should, "either specify the minimum initial enrichment or establish the specific source terms as operating controls and limits for cask use."

A specified source term is difficult for most cask users to determine and for inspectors to verify. The specification of a minimum initial enrichment is a more straightforward basis for defining the allowed contents. The specification should bound all assemblies proposed for the casks in the application. Specific limits are needed for inclusion in the Certificate of Compliance. Lower enriched fuel irradiated to the same burnup as higher enriched fuel produces a higher neutron source. Sometimes fuel assemblies are driven to burnups beyond the value normally expected for the given enrichment. According to the DOE Characteristic Data Base, the lower enrichment for fuel burned to 45,000 MWd/MTU is about 3.3 percent. The neutron source for an initial enrichment of 3.3 percent is expected to be 70 percent higher than the neutron source for 4.05 percent enriched fuel.

Recommendation:

Rewrite the last sentence of paragraph 1 in Chapter 5, Section V, 2 (page 5-3), to read "Consequently, the SAR should specify the minimum initial enrichment as an operating control and limit for cask use, or justify the use of a neutron source term, in the shielding analysis, that specifically bounds the neutron sources for fuel assemblies to be placed in the cask. Absent adequate justification acceptable to the staff, the SAR should not attempt to establish specific source terms as operating controls and limits for cask use."

YMP Position: Conform

Regulatory Guidance Document Number: ISG-11. [DIRS 170332]

Regulatory Guidance Title:

INTERIM STAFF GUIDANCE - 11, REVISION 3. CLADDING CONSIDERATIONS FOR THE TRANSPORTATION AND STORAGE OF SPENT FUEL.

Regulatory Position:

The staff has broadened the technical basis for the storage of spent fuel including assemblies with average burnups exceeding 45 GWd/MTU. This revision to Interim Staff Guidance No. 11 (ISG-11) addresses the technical review aspects of and specifies the acceptance criteria for limiting spent fuel reconfiguration in storage casks. It modifies the previous revision of the ISG in three ways: (1) by clarifying the meaning of some of the acceptance criteria contained in Revision 2, (2) by adding acceptance criteria to allow higher cladding temperature limits for certain conditions of storage, and (3) by providing justification for allowing licensees to continue to use the 570°C cladding temperature limit for short-term fuel loading operations of previously certified dry cask storage systems licensed to store low burnup (less than 45 GWd/MTU) spent fuel only.

The staff is currently reevaluating the technical basis for the transportation of spent fuel including assemblies with average assembly burnups exceeding 45 GWd/MTU. The staff is reviewing data and technical reports to further understand the mechanical and fracture toughness properties of spent fuel cladding in relation to the transportation of high burnup fuel under 10 CFR 71.55. Therefore, until further guidance is developed, the transportation of high burnup commercial spent fuel will be handled on a case-by-case basis using the criteria given in 10 CFR 71.55, 10 CFR 71.43(f), and 10 CFR 71.51.

This ISG focuses on the acceptance criteria needed to provide reasonable assurance that commercial spent fuel is maintained in the configuration that is analyzed in the SARs for spent fuel storage. Further, this guidance is applicable to all intact commercial spent fuel, independent of the burnup level, unless otherwise noted.

Recommendation:

The staff proposes that NUREG-1536, NUREG-1567, and NUREG-1617 be modified to add the acceptance criteria and staff review guidance contained in Appendix A. This ISG will result in modifications to the materials and containment or confinement chapters of these SRPs.

YMP Position: Conform with exception

The repository will adopt the temperature of 400°C for intact fuel for normal operating conditions. The YMP will adopt 570°C for intact fuel for accident conditions.

Regulatory Guidance Document Number: NUREG-0554. [DIRS 103347]

Regulatory Guidance Title:

SINGLE-FAILURE-PROOF CRANES FOR NUCLEAR POWER PLANTS

Regulatory Position:

Fuel storage and handling systems shall be designed to ensure adequate safety under normal and accident conditions. Overhead cranes are used to lift and transfer heavy component parts such as spent fuel casks. When a load being handled by a crane can be a direct or indirect cause of release of radioactivity, the load is called a critical load. The NRC has licensed reactors on the basis that the safe handling of critical loads can be accomplished by adding safety features to the handling equipment, by adding special features to the structures and areas over which the critical load is carried, or by a combination of the two. When reliance for the safe handling of critical loads is placed on the crane system itself, the system should be designed so that a single failure will not result in the loss of the capability of the system to safely retain the load.

YMP Position: Conform with exception

NUREG-0554 will be used as a guide.

Regulatory Guidance Document Number: NUREG-0612. [DIRS 104939]

Regulatory Guidance Title:

CONTROL OF HEAVY LOADS AT NUCLEAR POWER PLANTS.

Regulatory Position:

As indicated in NUREG-0612, one means for complying with the criteria of Section 5.1 is to demonstrate that no single failure in the heavy loads handling equipment will result in dropping of a load, as discussed in Section 5.1.6. One acceptable means of complying with the guidance of Section 5.1 was to meet the guidelines of NUREG-0554, "Single Failure Proof Cranes."

However, in the course of reviewing crane designs against NUREG-0554, concerns were identified of a generic nature which indicate that NUREG-0554, until revised, may be deficient in assuring single failure proof cranes. The concerns relate specifically to assuring that a single failure in the electric power control system will not cause a load drop.

YMP Position: Conform with exception

NUREG-0612 will be used as a guide.

Regulatory Guidance Document Number: NUREG-0700. Rev. 2. [DIRS 170780]

Regulatory Guidance Title:

HUMAN-SYSTEM INTERFACE DESIGN REVIEW GUIDELINES.

Regulatory Position:

The NRC staff reviews the human factors engineering (HFE) aspects of nuclear power plants in accordance with the Standard Review Plan (NUREG-0800). Detailed design review procedures are provided in the HFE Program Review Model (NUREG-0711). As part of the review process, the interfaces between plant personnel and plant systems and components are evaluated for conformance with HFE guidelines. The Human-System Interface Design Review Guidelines (NUREG-0700, Revision 2), provides the guidelines necessary to perform this evaluation. The review guidelines address the physical and functional characteristics of human-system interfaces

(HSIs). Since these guidelines only address the HFE aspects of design and not other related considerations, such as instrumentation and control and structural design, they are referred to as HFE guidelines. In addition to the review of actual HSIs, the NRC staff can use the NUREG-0700 guidelines to evaluate a design specific HFE guidelines document or style guide. The HFE guidelines are organized into four basic parts, which are divided into sections. Part I contains guidelines for the basic HSI elements: displays, user-interface interaction and management, and controls. These elements are used as building blocks to develop HSI systems to serve specific functions. Part II contains the guidelines for reviewing six such systems: alarm system, group-view display system, soft control system, computer-based procedure system, computerized operator support system, and communication system. Part III provides guidelines for the review of workstations and workplaces. Part IV provides guidelines for the review of HSI support, i.e., maintainability of digital systems.

YMP Position: Conform with exception

NUREG-0700 will be used as a guide.

Regulatory Guidance Document Number: **NUREG-0800. [DIRS 103124, 165110, 165111, 165112]**

Regulatory Guidance Title:

STANDARD REVIEW PLAN FOR THE REVIEW OF SAFETY ANALYSIS REPORTS FOR NUCLEAR POWER PLANTS.

Regulatory Position:

The Standard Review Plan (SRP) provides guidance to staff reviewers in the Office of Nuclear Reactor Regulation who perform safety reviews of applications to construct or operate nuclear power plants. The principal purpose of the SRP is to assure the quality and uniformity of staff review and to present a well-defined base from which to evaluate proposed changes in the scope and requirements of reviews. It is also a purpose of the SRP to make information about regulatory matters widely available and to improve communication and understanding of the staff review process by interested members of the public and the nuclear power industry.

This guide describes design requirements: 1) to mitigate the effects of natural phenomena such as wind, tornado, seismic, etc., 2) to specify steel and concrete design load combinations, and 3) to provide ALARA design guidance. Section 3.3.1.II.1) requires that the wind used in the design shall be the most severe wind that has been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data has been accumulated. This guide also describes Sepctrum II missiles generated as the result of tornado activity (Section 3.5.1.4). Spectrum II missiles are applicable for the YMP site as stated in the current analysis. The design load combinations listed for reinforced concrete are based on paragraphs II.3.b.(ii) and II.5.a of Section 3.8.4. The design load combinations for structural steel are based on paragraphs II.3.c.i(a), II.3.c.ii(a), and II.5.b of Section 3.8.4. Structures that are ITS shall be evaluated to demonstrate that the buildings are adequately stable against sliding and overturning effects. The listed load combinations for evaluating sliding and overturning are from Section 3.8.5. Resistance against overturning shall be evaluated by energy approach, and the effect of building sliding shall be evaluated by the use of energy or time history approaches. Foundations that are ITS or ITWI are required to be designed in accordance with the requirements of Section 3.8.5). Onsite facility areas are classified by radioactive material contamination levels (surface and airborne) to support the ALARA design process. This criterion is required to mitigate potential risk associated with radiation dose to occupational workers and the public, and as an element of engineering controls applied to the GROA to support the ALARA philosophy (Section 12.3).

YMP Position: Conform with exception

NUREG-0800 will be conformed with as noted above.

Regulatory Guidance Document Number: NUREG-1065, Rev 2. [DIRS 169589]

Regulatory Guidance Title:

ACCEPTABLE STANDARD FORMAT AND CONTENT FOR THE FUNDAMENTAL NUCLEAR MATERIAL CONTROL (FNMC) PLAN REQUIRED FOR LOW-ENRICHED URANIUM FACILITIES

Regulatory Position:

An applicant's FNMC plan must demonstrate how the basic capabilities specified in 10 CFR 74.31(c) are achieved and maintained and how such capabilities are used to achieve the performance objectives listed in 10 CFR 74.31(a). After accepting an FNMC plan and imposing it as a condition of license, the NRC will judge the adequacy of a licensee's materials control and accountability (MC&A) performance by inspecting for compliance with commitments and practices described in the plan.

YMP Position: Conform with exception

The repository will conform to the requirements of 10 CFR 63.78, which incorporates the requirements of 10 CFR 72.72, 10 CFR 72.74, 10 CFR 72.76, and 10 CFR 72.78. NUREG-1065 will be used as guidance.

Regulatory Guidance Document Number: NUREG-1280, Rev 1. [DIRS 159029]

Regulatory Guidance Title:

STANDARD FORMAT AND CONTENT ACCEPTANCE CRITERIA FOR THE MATERIAL CONTROL AND ACCOUNTING (MC&A) REFORM AMENDMENT

Regulatory Position:

In 1987 the NRC revised the MC&A requirements for NRC licensees authorized to possess and use a formula quantity (i.e., 5 formula kilograms or more) of strategic special nuclear material. Those revisions issued as 10 CFR 74.51-59 require timely monitoring of in-process inventory and discrete items to detect anomalies potentially indicative of material losses. Timely detection and enhanced loss localization capabilities are beneficial to alarm resolution and also for material recovery in the event of an actual loss. NUREG-1280 was issued in 1987 to present criteria that could be used by applicants, licensees, and NRC license reviewers in the initial preparation and subsequent review of fundamental nuclear material control (FNMC) plans submitted in response to the Reform Amendment. This document is also intended for both licensees and license reviewers with respect to FNMC plan revisions. General performance objectives, system capabilities, process monitoring, item monitoring, alarm resolution, quality assurance, and accounting are addressed. This revision to NUREG-1280 is an expansion of the initial edition, which clarifies and expands upon several topics and addresses issues identified under Reform Amendment implementation experience.

YMP Position: Conform with exception

The repository will conform to the requirements of 10 CFR 63.78, which incorporates the requirements of 10 CFR 72.72, 10 CFR 72.74, 10 CFR 72.76, and 10 CFR 72.78. NUREG-1280 will be used as guidance.

Regulatory Guidance Document Number: **NUREG-1451 (McConnell et al. 1992 [DIRS 105205])**

Regulatory Guidance Title:

STAFF TECHNICAL POSITION ON INVESTIGATIONS TO IDENTIFY FAULT DISPLACEMENT HAZARDS AND SEISMIC HAZARDS AT A GEOLOGIC REPOSITORY

Regulatory Position:

The purpose of this staff technical position is to provide guidance to the DOE on acceptable geologic repository investigations that can be used to identify fault displacement hazards and seismic hazards. However, detailed analyses of fault displacement and seismic data, such as those required for comprehensive assessments of repository performance, may identify the need for additional investigations.

YMP Position: Conform with exceptions

The DOE intends to conform to staff technical positions in NUREG-1451 (McConnell and Lee 1994 [DIRS 110957]) with exceptions as follows:

- Section 3.1.1—Conform

- Section 3.1.2—Exception. While the project's initial identification of faults that require detailed investigation is consistent with the guidance, the formal process described was not followed. Faults in and near the controlled area were evaluated to determine if they should be investigated in detail, but the faults were not classified as Type II or Type III using the NUREG-1451 (McConnell and Lee 1994 [DIRS 110957]) criteria.

- Section 3.1.3—Exception. While the project's identification of faults that require detailed investigation is consistent with the guidance, the formal process described was not followed. Faults in and near the controlled area were evaluated to determine whether they should be investigated in detail, but the faults were not classified as Type I, II, or III using the NUREG-1451 (McConnell and Lee 1994 [DIRS 110957]) criteria.

- Section 3.1.4—Exception. While the project's identification of faults that require detailed investigation is consistent with the guidance, the formal process described was not followed. That is, there is no documentation of a periodic re-evaluation of faults in and near the controlled area in light of site characterization results and development of alternative tectonic models.

- Section 3.2—Conform.

- Section 3.3 (1)—Conform

- Section 3.3 (2)—Conform

- Section 3.3 (3)—Exception. The project does not intend to estimate ground acceleration and duration of shaking at Yucca Mountain from historical earthquakes.

- Section 3.3 (4)—Conform

- Section 3.3 (5)—Conform

- Section 3.3 (6) (a)—Exception. Expert elicitation determined which faults are important in a consideration of vibratory ground motion for design, not a deterministic assessment of which faults might generate ground acceleration greater than 0.1 g at the site.

- Section 3.3 (6) (b)—Exception. While the project determined fault parameters for faults that may be important in establishing the design basis vibratory ground motion, the NUREG-1451 (McConnell and Lee 1994 [DIRS 110957]) acceptable process and criteria for Type I fault identification and evaluation was not formally followed.

Regulatory Guidance Document Number: **NUREG-1494 (McConnell and Lee 1994 [DIRS 110957])**

Regulatory Guidance Title:

STAFF TECHNICAL POSITION ON CONSIDERATION OF FAULT DISPLACEMENT HAZARDS AND SEISMIC HAZARDS AT A GEOLOGICAL REPOSITORY

Regulatory Position:

NRC regulations for the disposal of SNF and HLW in a repository recognize that fault displacement is a potentially adverse condition (10 CFR 63.122(c)(11) and 63.122(c)(20)). However, they do not prohibit designing the repository against the effects of such a potentially adverse condition. This staff technical position recognizes the acceptability of designing the repository to take into account the attendant effects (e.g., displacement) of faults of regulatory concern and expresses the staff's views on what is needed from the DOE if it chooses to locate ITS or ITWI SSCs in areas that contain faults of regulatory concern.

YMP Position: Conform with exception

The DOE intends to conform to staff technical positions in NUREG-1451 (McConnell et al. 1992 [DIRS 105205]) with exceptions, as follows:

3 (1) Conform. However, no formal process has been implemented by the project to identify Type I faults.

3 (2) Conform with the guidance that Type I faults should be avoided where this can be reasonably achieved. However, no formal process has been implemented by the project to identify type faults.

Exception to the 3 (2) (b) guidance that, "if DOE chooses to locate ITS or ITWI SSCs in areas that contain 'Type I' faults ... DOE must be able to demonstrate, with reasonable assurance, that any proposed geologic repository designed to accommodate the effects of faulting meets the 10 CFR Part 60 design criteria, and pre- and post-closure performance objectives." Rather DOE will demonstrate, with reasonable assurance, that any proposed geologic repository designed to accommodate the effects of faulting meets the 10 CFR Part 63 [DIRS 173273] preclosure and postclosure performance objectives.

Regulatory Guidance Document Number: NUREG-1520. [DIRS 159567]

Regulatory Guidance Title:

STANDARD REVIEW PLAN FOR THE REVIEW OF A LICENSE APPLICATION FOR A FUEL CYCLE FACILITY

Regulatory Position:

Standard review plan (SRP) NUREG-1520 provides NRC guidance for reviewing and evaluating the health, safety, and environmental protection aspects of applications for licenses to possess and use special nuclear material (SNM) to produce nuclear reactor fuel. This guidance also applies to the review and evaluation of proposed amendments and license renewal applications for nuclear fuel cycle facilities. The principal purpose of this SRP is to ensure the quality and uniformity of reviews conducted by the staff of the NRC's Office of Nuclear Material Safety and Safeguards (NMSS). This SRP also provides a well-defined foundation from which to evaluate proposed changes in the scope, level of detail, and acceptance criteria of reviews. Another important purpose of this SRP is to make information about regulatory reviews widely available and to improve communication and understanding of the staff review process. In addition, because this SRP describes the scope, level of detail, and acceptance criteria for reviews, it serves as regulatory guidance for applicants who need to determine what information to present in a license application and related documents.

YMP Position: Conform with exception

NUREG-1520 will be used as a guide.

Regulatory Guidance Document Number: NUREG-1536. [DIRS 101903]

Regulatory Guidance Title:

STANDARD REVIEW PLAN FOR DRY CASK STORAGE SYSTEMS

Regulatory Position:

Standard review plan (SRP) NUREG-1536 provides guidance for use by staff reviewers from the NRC, Office of Nuclear Material Safety and Safeguards (NMSS), Spent Fuel Project Office, in performing safety reviews of applications for approval of spent fuel dry cask storage systems (DCSS). The principal purposes of the DCSS SRP are to ensure the quality and consistency of staff reviews and to establish a well-defined basis from which to evaluate proposed changes in the scope of reviews.

YMP Position: Conform with exception

NUREG-1536 will be used as a guide.

Regulatory Guidance Document Number: NUREG-1567. [DIRS 149756]

Regulatory Guidance Title:

STANDARD REVIEW PLAN FOR SPENT FUEL DRY STORAGE FACILITIES.

Regulatory Position:

NUREG-1567 is the Facility Standard Review Plan (FSRP). It is intended to provide guidance to the NRC staff who will be conducting a safety review of a site-specific license application for an independent spent fuel storage installation (ISFSI).

YMP Position: Conform with exception

NUREG-1567 will be used as a guide.

Regulatory Guidance Document Number: NUREG-1617. [DIRS 154000]

Regulatory Guidance Title:

STANDARD REVIEW PLAN FOR TRANSPORTATION PACKAGES FOR SPENT NUCLEAR FUEL.

Regulatory Position:

Standard review plan (SRP) NUREG-1617 provides guidance for use by staff for transportation packages for SNF under 10 CFR Part 71. The SRP is intended for use by NRC staff reviewers of package applications, amendments, and renewals. The SRP provides specific guidance for the staff's preparation of NRC safety evaluation report (SER). The SRP provides guidance relating to compliance with 10 CFR Part 71, and portions of other CFR titles and parts incorporated by reference in or applicable to 10 CFR Part 71.

YMP Position: Conform with exception

NUREG-1617 will be used as a guide.

Regulatory Guidance Document Number: **NUREG-1804, Rev. 2. [DIRS 163274]**

Regulatory Guidance Title:

YUCCA MOUNTAIN REVIEW PLAN, FINAL REPORT.

Regulatory Position:

The Yucca Mountain Review Plan provides guidance for the NRC staff to evaluate a DOE license application for a geologic repository. It is not a regulation and does not impose regulatory requirements. The principal purpose of the Yucca Mountain Review Plan is to ensure the quality, uniformity, and consistency of NRC staff reviews of the license application and any requested amendments. The Yucca Mountain Review Plan has separate sections for reviews of general information, repository safety before permanent closure, repository safety after permanent closure, the research and development program to resolve safety questions, the performance confirmation program, and administrative and programmatic requirements. Each section addresses determining compliance with specific regulatory requirements from 10 CFR Part 63. The regulations and the Yucca Mountain Review Plan are risk-informed, performance-based to the extent practical.

YMP Position: Conform

Regulatory Guidance Document Number: **NUREG/CR-6407. [DIRS 132324]**

Regulatory Guidance Title:

CLASSIFICATION OF TRANSPORTATION PACKAGING AND DRY SPENT FUEL STORAGE SYSTEM COMPONENTS ACCORDING TO IMPORTANCE TO SAFETY

Regulatory Position:

This report describes a method for determining the classification of components used in transportation packagings and dry spent fuel storage systems. This approach provides a method for identifying the classification of components according to importance to safety within transportation packagings and dry spent fuel storage systems. A review was performed of the rules, regulations, regulatory guidance, and various reports associated with the design, fabrication, and certification of transportation packagings and spent fuel storage systems. Discussions were held with several suppliers and fabricators of packagings and storage containers to establish current practices. This report also includes a list of generic components for each of the general types of transportation packagings and spent fuel storage systems. The safety importance of each component is discussed, and a classification category is assigned.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.12, Rev. 2 [DIRS 103170]**

Regulatory Guidance Title:

NUCLEAR POWER PLANT INSTRUMENTATION FOR EARTHQUAKES

Regulatory Position:

The type, locations, operability, characteristics, installation, actuation, remote indication, and maintenance of seismic instrumentation described in Section C are acceptable to the NRC staff for satisfying the requirements in 10 CFR Part 20 and 10 CFR Part 50, Paragraph IV(a)(4) of Appendix S, for ensuring the safety of nuclear power plants.

YMP Position: Conform with exception

This guide was written for commercial nuclear power power plants, and the repository does not have a containment structure.

Regulatory Guidance Document Number: **Reg Guide 1.21, Rev. 1 [DIRS 105991]**

Regulatory Guidance Title:

MEASURING, EVALUATING, AND REPORTING RADIOACTIVITY IN SOLID WASTES AND RELEASES OF RADIOACTIVE MATERIALS IN LIQUID AND GASEOUS EFFLUENTS FROM LIGHT-WATER-COOLED NUCLEAR POWER PLANTS

Regulatory Position:

This guide describes programs acceptable to the NRC for measuring, reporting, and evaluating releases of radioactive materials in liquid and gaseous effluents and guidelines for classifying and reporting the categories and curie content of solid wastes.

YMP Position: Conform with exception

YMP conforms with this guide to the extent discussed below. The requirement for hourly meteorological data for batch releases will be met if the batch releases are made in a nonrandom manner. If the batch releases are made in a random manner, average annual meteorological parameters will be used for these calculations and the hourly meteorological data will not have to be included in the radioactive effluent reports. This methodology is representative for dose calculations and is less susceptible to errors in data management.

Regulatory Guidance Document Number: **Reg Guide 1.23, Rev. 0 [DIRS 103640]**

Regulatory Guidance Title:

ONSITE METEOROLOGICAL PROGRAMS

Regulatory Position:

This guide describes a suitable onsite meteorological program to provide meteorological data needed to estimate potential radiation doses to the public as a result of the routine or accidental release of radioactive materials to the atmosphere and to assess other environmental effects.

YMP Position: Conform with exception

This regulatory guide describes meteorological measurement programs acceptable to the NRC for providing meteorological data for estimating potential radiation doses to the public resulting from routine releases or from postulated accidents. Because required meteorological measurements are independent of the type of facility being evaluated, all the positions recommended in this guide are considered potentially useful to the repository. The concept of emergency preparedness, as recommended in Position 8 of this guide, aims primarily at monitoring local meteorological conditions and their effect on the released radioactivity following an accident at a nuclear power plant. For the repository it is unlikely that an accident will occur that is potentially as severe as that of a loss-of-coolant accident at a nuclear power plant. In general, YMP will conform to the meteorological parameters, data recorders, instrument accuracy, maintenance, and data reduction provision of this regulatory guide. The YMP site is large and has complex air flow patterns. Special meteorological instruments at multiple locations will be provided, as required, to monitor potential releases at various site locations.

Regulatory Guidance Document Number: **Reg Guide 1.25, Rev. 0 [DIRS 107691]**

Regulatory Guidance Title:

ASSUMPTIONS USED FOR EVALUATING THE POTENTIAL RADIOLOGICAL CONSEQUENCES OF A FUEL HANDLING ACCIDENT IN THE FUEL HANDLING AND STORAGE FACILITY FOR BOILING AND PRESSURIZED WATER REACTORS

Regulatory Position:

This guide provides acceptable assumptions that may be used in evaluating the radiological consequences of a fuel handling accident in light water reactors (LWRs). These assumptions are:

1. The assumptions related to the release of radioactive material from the fuel and fuel storage facility as a result of a fuel handling accident

2. The assumptions for atmospheric dispersion

3. The assumptions used to obtain conservative approximations of thyroid dose from the inhalation of radioiodine and external whole body doses from radioactive clouds.

YMP Position: Conform with exception

YMP conforms to the intent of this regulatory guide in that worst case source terms for release from CSNF are made and assumptions for atmospheric dispersion are appropriately conservative. However, this regulatory guide is based on an accident in a spent fuel pool for a high burnup fuel assembly just out of core. In this scenario, Iodine 131-135 dominate dose. This is not the case at YMP where fuel has been out of the reactor at least 5 years and is handled dry.

Regulatory Guidance Document Number: Reg Guide 1.52, Rev. 3 [DIRS 171692]

Regulatory Guidance Title:

DESIGN, INSPECTION, AND TESTING CRITERIA FOR AIR FILTRATION AND ADSORPTION UNITS OF POST-ACCIDENT ENGINEERED-SAFETY-FEATURE ATMOSPHERE CLEANUP SYSTEMS IN LIGHT-WATER-COOLED NUCLEAR POWER PLANTS

Regulatory Position:

This guide provides guidance and criteria acceptable to the NRC staff for meeting NRC regulations in 10 CFR Part 50, Appendix A, with regard to the design, inspection, and testing of air filtration and iodine adsorption units of engineered-safety-feature atmosphere cleanup systems in light-water-cooled nuclear power plants. 10 CFR Part 50, General Design Criterion 61 of Appendix A, requires that fuel storage and handling systems, radioactive waste systems, and other systems that may contain radioactivity be designed to ensure adequate safety under normal and postulated accident conditions and they be designed with an appropriate containment, confinement, and filtering system. For the purpose of this guide, engineered-safety-feature atmosphere cleanup systems are those systems that are credited in the licensee's current design basis accident analysis, as described in the safety analysis report.

The regulatory position is subdivided as follows:

- C.1 General design and testing criteria
- C.2 Environmental design criteria
- C.3 System design criteria
- C.4 Component design criteria and qualification testing
- C.5 Maintainability criteria
- C.6 In place testing criteria
- C.7 Laboratory testing criteria for activated carbon.

YMP Position: Conform with exception

Regulatory Position C.1 and C.3 through C.6—The design of the ITS HEPA filter plenums and associated components will use ASME AG-1-2003 [DIRS 166908] instead of the referenced ASME AG-1-1997 and ASME AG1a-2000.

C.7 and Table 1—This regulatory position is not applicable since there is no requirement for charcoal adsorbers to be installed in the system.

C.3.1 and C.3.2—The current design of the ITS HEPA filter plenums does not have full redundancy and physical separation as it is not required by the reliability analysis. Standby units will be provided instead.

C.3 through C.5—The DOE-HDBK-1169-2003 [DIRS 167097] will be used as a guidance document instead of the referenced ERDA 76-21. The DOE-HDBK-1169-2003 succeeds three previous editions of the Nuclear Air Cleaning Handbook: ERDA 76-21, *Nuclear Air Cleaning Handbook* (1976); ORNL/NSIC-65, *Design, Construction and Testing of High-Efficiency Air Filtration Systems for Nuclear Applications* (1970); and NSIC-13, *Filters, Sorbents, and Air Cleaning Systems as Engineered Safeguards in Nuclear Installations* (1966).

Regulatory Guidance Document Number: Reg Guide 1.53, Rev. 2 [DIRS 171817]

Regulatory Guidance Title:

APPLICATION OF THE SINGLE-FAILURE CRITERION TO SAFETY SYSTEMS

Regulatory Position:

Conformance with the requirements of IEEE Std 379-2000 provides methods acceptable to the NRC staff for satisfying NRC regulations with respect to the application of the single-failure criterion to the electrical power, instrumentation, and control portions of nuclear power plant safety systems.

IEEE Std 379-2000, Section 2, references several industry codes and standards. If a referenced standard has been separately incorporated into NRC regulations, licensees and applicants must comply with the standard as set forth in the regulation. If the referenced standard has been endorsed by the NRC staff in a regulatory guide, the standard constitutes an acceptable method of meeting a regulatory requirement as described in the regulatory guide. If a referenced standard has been neither incorporated into the NRC's regulations nor endorsed in a regulatory guide, licensees and applicants may consider and use the information in the referenced standard, if appropriately justified, consistent with regulatory practice.

YMP Position: Conform with exception

Explanation of exception will be added later.

Regulatory Guidance Document Number: **Reg Guide 1.59, Rev. 2 [DIRS 131488]**

Regulatory Guidance Title:

DESIGN BASIS FLOODS FOR NUCLEAR POWER PLANTS

Regulatory Position:

This guide discussed the design basis floods that nuclear power plants should be designed to withstand without loss of capability for cold shutdown and maintenance thereof. The design requirements for flood protection are the subject of Regulatory Guide 1.102.

YMP Position: Conform with exceptions

Where this guide refers to safety-related SSCs identified in Regulatory Guide 1.29 [DIRS 103311], replace the SSCs with ITS. In addition, the term cold shutdown has no meaning at the repository and, therefore, will not be considered.

Regulatory Guidance Document Number: **Reg Guide 1.61, Rev. 0 [DIRS 149473]**

Regulatory Guidance Title:

DAMPING VALUES FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS

Regulatory Position:

This guide delineates damping values acceptable to the NRC regulatory staff to be used in the elastic modal dynamic seismic analysis of seismic Category I SSCs. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

YMP Position: Conform

YMP conforms with the intent of this Regulatory Guide utilizing the damping values provided in the dynamic system analysis for SSCs ITS.

Regulatory Guidance Document Number: **Reg Guide 1.62, Rev. 0 [DIRS 103116]**

Regulatory Guidance Title:

MANUAL INITIATION OF PROTECTIVE ACTIONS

Regulatory Position:

C.1 Means should be provided for manual initiation of each protective action (e.g., reactor trip, containment isolation) at the system level, regardless of whether means are also provided to initiate the protective action at the component or channel level (e.g., individual control rod, individual isolation valve).

C.2 Manual initiation of a protective action at the system level should perform all actions performed by automatic initiation such as starting auxiliary or supporting systems, sending signals to appropriate valve-actuating mechanisms to ensure correct valve position, and providing the required action sequencing functions and interlocks.

C.3 The switches for manual initiation of protective actions at the system level should be located in the control room and be easily accessible to the operator so that action can be taken in an expeditious manner.

C.4 The amount of equipment common to manual and automatic initiation should be kept to a minimum. It is preferable to limit such common equipment to the final actuation devices and the actuated equipment. However, action sequencing functions and interlocks (of Position 2) associated with the final actuation devices and actuated equipment may be common if individual manual initiation at the component or channel level is provided in the control room. No single failure within the manual, automatic, or common portions of the protection system should prevent initiation of protective action by manual or automatic means.

C.5 Manual initiation of protective actions should depend on the operation of a minimum of equipment, consistent with 1, 2, 3, and 4 above.

C.6 Manual initiation of protective action at the system level should be so designed that when initiated, it will go to completion as required in IEEE Std 603-1991, Section 4.16.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.76, Rev. 0 [DIRS 106281]**

Regulatory Guidance Title:

DESIGN BASIS TORNADO FOR NUCLEAR POWER PLANTS

Regulatory Position:

Nuclear power plants should be designed to withstand the design basis tornado. The values or the parameters specified in Table 1 for the appropriate regions of Figure 1 are generally acceptable to the regulatory staff for defining the design basis tornado for a nuclear power plant. Sites located near the general boundaries of adjoining regions may involve additional consideration.

If a design basis tornado proposed for a given site is characterized by less conservative values for the parameters than the regional values in Table 1, a comprehensive analysis should be provided to justify the selection of the less conservative design basis tornado.

YMP Position: Conform with exception

Applicable with exception or alternative approach. The PSA for the repository will identify any event sequences and associated SSCs that are potentially vulnerable to tornado or tornado missile initiated event sequences. Therefore, a prescriptive list of SSCs or systems to be protected is not appropriate to the repository. Design criteria to withstand tornado wind speeds and missiles will be applied, as appropriate to SSC ITS, to ensure that the repository is compliant with the risk-informed, performance-based requirements of 10 CFR Part 63 [DIRS 173273].

The selection of design parameters for the design basis tornado for the repository site will take exception to Regulatory Position C.1 and not apply the Region III parameters listed in Table 1.

One of two alternative approaches will be applied:

1. Application of tornado parameters given in NUREG/CR-4461 (Ramsdell and Andrews 1986 [DIRS 103693]). This is regarded as an updated to the Table 1 data and provides conservative design parameters.

2. Application of site-specific meteorological data that supports lower maximum wind speeds for credible tornadoes in keeping with the risk-informed licensing basis. This approach is in accordance with C.2, but requires analysis to justify the less conservative parameters.

Regulatory Guidance Document Number: Reg Guide 1.89, Rev. 1 [DIRS 102609]

Regulatory Guidance Title:

ENVIRONMENTAL QUALIFICATION OF CERTAIN ELECTRIC EQUIPMENT IMPORTANT TO SAFETY FOR NUCLEAR POWER PLANTS

Regulatory Position:

The procedures described by IEEE Std 323-1974 are acceptable to the NRC staff for satisfying NRC regulations pertaining to the qualification of electric equipment for service in nuclear power plants to ensure that the equipment can perform its safety functions. (See regulatory guide for clarifications.)

YMP Position: Conform with exeption

YMP will use IEEE Std 323™-2003 [DIRS 166907].

Regulatory Guidance Document Number: Reg Guide 1.91, Rev. 1 [DIRS 103638]

Regulatory Guidance Title:

EVALUATION OF EXPLOSIONS POSTULATED TO OCCUR ON TRANSPORTATION ROUTES NEAR NUCLEAR POWER PLANTS

Regulatory Position:

In the design of nuclear power plants, the ability to withstand the possible effects of explosions occurring on nearby transportation routes should be considered. The following methods are acceptable to the NRC staff for ensuring that the risk of damage due to an explosion on a nearby transportation route is sufficiently low.

1. When carriers that transport explosives can approach vital structures of a nuclear facility no closer than the distances computed using Figure 1, no further consideration need be given to the effects of a blast in plant design. In calculating trinitrotoluene (TNT) equivalents, assumptions of 100 percent TNT (mass) equivalence for solid energetic materials and 240 percent TNT (mass) equivalence for substances subject to vapor phase explosions are acceptable upper bounds when effective yields generated from test data do not exist. Lower effective yields may be justified by analyses accounting for reaction kinetics, site topography, and prevailing meteorological conditions when the hazardous cargoes can be identified.

2. If transportation routes are closer to structures and systems ITS than the distances computed using Figure 1, the applicant may show that the risk is acceptably low on the basis of low probability of explosions. A demonstration that the rate of exposure to a peak positive incident overpressure in excess of 1 psi (7 kPa) is less than 10(-6) per year, when based on conservative assumptions, or 10(-7) per year, when based on realistic assumptions, is acceptable. Due consideration should be given to the comparability of conditions on the route to those of the accident database.

3. If transportation routes are closer to structures and systems ITS than the distances computed using Figure 1, the applicant may show that the risk to the public is acceptably low on the basis of capability of the safety-related structures to withstand blast and missile effects associated with detonation of the hazardous cargo. In assessing the capacity of structures to resist blast loads, a simplified quasi-static analysis of blast effects using the load combination of Equation (4) is acceptable. Effective yields based on analyses accounting for reaction kinetics, site topography, and prevailing meteorological conditions can be used when justified.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.92, Rev. 1 [DIRS 151403]**

Regulatory Guidance Title:

COMBINING MODAL RESPONSES AND SPATIAL COMPONENTS IN SEISMIC RESPONSE ANALYSIS

Regulatory Position:

This guide describes the procedures to be used for combining modal responses of individual modes and the combination of effects due to the three independent spatial components of an earthquake in seismic analyses of nuclear power plant SSCs.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.100, Rev. 2 [DIRS 110810]**

Regulatory Guidance Title:

SEISMIC QUALIFICATION OF ELECTRIC AND MECHANICAL EQUIPMENT FOR NUCLEAR POWER PLANTS

Regulatory Position:

The procedures described by ANSI/IEEE Std 344-1987 (Reaffirmed 1993) are acceptable to the NRC staff for satisfying NRC regulations pertaining to the seismic qualification of electric and mechanical equipment subject to the following:

For mechanical equipment, thermal distortion effects on operability should be considered and loads imposed by the attached piping should also be accounted for.

If dynamic testing of a pump or valve assembly is impracticable, static testing of the assembly is acceptable provided that (1) the end loadings are applied and are equal to or greater than postulated event loads, (2) all dynamic amplification effects are accounted for, (3) the component is in the operating mode during and after the application of loads, and (4) an adequate analysis is made to show the validity of the static application of loads.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.102, Rev. 1 [DIRS 117499]**

Regulatory Guidance Title:

FLOOD PROTECTION FOR NUCLEAR POWER PLANTS

Regulatory Position:

This guide describes the types of flood protection acceptable to the NRC staff for the safety-related SSCs.

YMP Position: Conforms with exception

Explanation of exception will be added later.

Regulatory Guidance Document Number: **Reg Guide 1.105, Rev. 3 [DIRS 165738]**

Regulatory Guidance Title:

SETPOINTS FOR SAFETY-RELATED INSTRUMENTATION

Regulatory Position:

Conformance with ANSI/ISA-67.04-1991, *Setpoints for Nuclear Safety-Related Instrumentation*, Part 1, with the following exceptions and clarifications, provides a method acceptable to the NRC staff for satisfying NRC regulations for ensuring that setpoints for safety-related instrumentation are established and maintained within the technical specification limits.

1. ANSI/ISA-67.04-2000, Section 4, specifies the methods, but not the criterion, for combining uncertainties in determining a trip setpoint and its allowable values. The 95/95 tolerance limit is an acceptable criterion for uncertainties. That is, there is a 95 percent probability that the constructed limits contain 95 percent of the population of interest for the surveillance interval selected.

2. ANSI/ISA-67.04-1994, Sections 7 and 8 of Part 1, references several industry codes and standards. If a referenced standard has been incorporated separately into NRC regulations, licensees and applicants must comply with that standard as set forth in the regulation. If the referenced standard has been endorsed in a regulatory guide, the standard constitutes a method acceptable to the NRC staff of meeting a regulatory requirement as described in the regulatory guide. If a referenced standard has been neither incorporated into NRC regulations nor endorsed in a regulatory guide, licensees and applicants may consider and use the information in the referenced standard if appropriately justified, consistent with current regulatory practice.

3. ANSI/ISA-67.04-1994, Section 4.3, states that the limiting safety system setting may be maintained in technical specifications or appropriate plant procedures. However, 10 CFR 50.36 states that the technical specifications will include items in the categories of safety limits, limiting safety system settings, and limiting control settings. Therefore, the limiting safety system setting may not be maintained in plant procedures. Rather, the limiting safety system setting must be specified as a technical-specification-defined limit in order to satisfy the requirements of 10 CFR 50.36. The limiting safety system setting should be developed in accordance with the setpoint methodology set forth in the standard, with the limiting safety system setting listed in the technical specifications.

4. ANSI/ISA-67.04-1991 [DIRS 164201] provides a discussion on the purpose and application of an allowable value. The allowable value is the limiting value that the trip setpoint can have when tested periodically, beyond which the instrument channel is considered inoperable and corrective action must be taken in accordance with the technical specifications. The allowable value relationship to the setpoint methodology and testing requirements in the technical specifications must be documented.

YMP Position: Conform

Regulatory Guidance Document Number: Reg Guide 1.109, Rev. 1 [DIRS 100067]

Regulatory Guidance Title:

CALCULATION OF ANNUAL DOSES TO MAN FROM ROUTINE RELEASES OF REACTOR EFFLUENTS FOR THE PURPOSE OF EVALUATING COMPLIANCE WITH 10 CFR PART 50, APPENDIX I

Regulatory Position:

Equations are provided in C.1, C.2, and C.3 by which the NRC staff will estimate radiation exposure for maximum individuals and the population within 50 miles. These equations are appropriate for the exposure pathways that the staff routinely considers in its evaluations. In addition, other exposure pathways that may arise due to unique conditions at a specific site should be considered if they are likely to provide a significant contribution to the total dose. A pathway is considered significant if a conservative evaluation yields an additional dose increment equal to or more than 10 percent of the total from all pathways considered in this guide.

1. Doses from Liquid Effluent Pathways
2. Gamma and Beta Doses from Noble Gases Discharged to the Atmosphere
3. Doses from Radionuclides and Other Radionuclides Released to the Atmosphere
4. Integrated Doses to the Population
5. Summary of Staff Position.

YMP Position: Conform with exceptions

The repository conforms with exception to this guide. This guide is only applicable to preclosure operations of the repository. Position 1 C.1 is not applicable because the repository design does not have radioactive liquid effluents. C.2 through C.3 describe the equations used to estimate individual doses from gaseous pathways. These models can be adapted to estimate releases from the repository due to routine operations. Position 4 describes the method for estimating population doses and how it can be used for the repository without modification. Position 5 is applicable except for dose limits for liquid pathways. The appendices to this guide also have to be modified to include parameters (e.g., inhalation dose factors) for those radionuclides that exist in HLW.

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 1.117, Rev. 1 [DIRS 144751]

Regulatory Guidance Title:

TORNADO DESIGN CLASSIFICATION

Regulatory Position:

SSCs ITS that should be protected from the effects of a design basis tornado are:

1. Those necessary to ensure the integrity of the reactor coolant pressure boundary

2. Those necessary to ensure the capability to shutdown the reactor and maintain it in a safe shutdown condition (this includes hot standby and cold shutdown capability)

3. Those whose failure could lead to radioactive release resulting in calculated offsite exposures greater than 25 percent of the guideline exposures of 10 CFR Part 100 using appropriately conservative analytical methods and assumptions.

YMP Position: Conform with exception

YMP conforms to the intent but not the specifics.

Regulatory Guidance Document Number: Reg Guide 1.122, Rev. 1 [DIRS 151404]

Regulatory Guidance Title:

DEVELOPMENT OF FLOOR DESIGN RESPONSE SPECTRA FOR SEISMIC DESIGN OF FLOOR-SUPPORTED EQUIPMENT OR COMPONENTS

Regulatory Position:

This guide describes the procedures acceptable to the NRC for combining and smoothing the floor response spectra, with peaks broadened, to obtain the floor design response spectra.

YMP Position: Conform

Regulatory Guidance Document Number: Reg Guide 1.140, Rev. 2 [DIRS 158855]

Regulatory Guidance Title:

DESIGN, TESTING, AND MAINTENANCE CRITERIA FOR NORMAL VENTILATION EXHAUST SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS

Regulatory Position:

This guide provides guidance and criteria acceptable to the NRC staff for meeting the NRC regulations with regard to the design, inspection, and testing of air filtration and adsorption units installed in the normal atmosphere cleanup systems of light-water-cooled nuclear power plants. This guide applies only to atmosphere cleanup systems designed to collect airborne radioactive materials during normal plant operation, including anticipated operational occurrences. The regulatory position is subdivided as follows:

C.1 General design criteria and testing
C.2 Environmental design criteria
C.3 System design criteria
C.4 Component design criteria and qualification testing
C.5 Maintainability criteria
C.6 In place testing criteria
C.7 Laboratory testing criteria for activated carbon.

YMP Position: Conform with exception

Regulatory Position C.1 and C.3 through C.6—The design of the HEPA filter plenums and associated components will use ASME AG-1-2003 [DIRS 166908] instead of the referenced ASME AG-1-1997 and ASME AG1a-2000.

C.7 and Table 1—This regulatory position is not applicable since there is no requirement for charcoal adsorbers to be installed in the system.

C.3 through C.5—The DOE-HDBK-1169-2003 [DIRS 167097] published by DOE will be used as a guidance document instead of the referenced ERDA 76-21. The DOE-HDBK-1169-2003 succeeds three previous editions of ERDA 76-21, *Nuclear Air Cleaning Handbook* (1976); ORNL/NSIC-65, *Design, Construction and Testing of High-Efficiency Air Filtration Systems for Nuclear Applications* (1970); and NSIC-13, *Filters, Sorbents, and Air Cleaning Systems as Engineered Safeguards in Nuclear Installations* (1966).

Regulatory Guidance Document Number: Reg Guide 1.143, Rev. 2 [DIRS 157566]

Regulatory Guidance Title:

DESIGN GUIDANCE FOR RADIOACTIVE WASTE MANAGEMENT SYSTEMS, STRUCTURES, AND COMPONENTS INSTALLED IN LIGHT-WATER-COOLED NUCLEAR POWER PLANTS

Regulatory Position:

This guide furnishes design guidance acceptable to the NRC regarding seismic and quality group classification and quality assurance provisions for radioactive waste management SSCs.

YMP Position: Conform

Regulatory Guidance Document Number: Reg Guide 1.145, Rev. 1 [DIRS 103651]

Regulatory Guidance Title:

ATMOSPHERIC DISPERSION MODELS FOR POTENTIAL ACCIDENT CONSEQUENCE ASSESSMENTS AT NUCLEAR POWER PLANTS

Regulatory Position:

This guide identifies acceptable methods for:

1. Calculating atmospheric relative concentration (χ/Q) values
2. Determining χ/Q values on an overall site basis
3. Determining χ/Q values on a directional basis
4. Choosing χ/Q values to be used in evaluations of the types of loss of coolant accident events for pressurized water reactor and boiling water reactor plants.

YMP Position: Conform

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 1.152, Rev. 1 [DIRS 103164]

Regulatory Guidance Title:

CRITERIA FOR DIGITAL COMPUTERS IN SAFETY SYSTEMS OF NUCLEAR POWER PLANTS

Regulatory Position:

Conformance with the requirements of IEEE Std 7-4.3.2-1993, with the exception of relying solely on quantitative reliability goals (Section 5.15), is a method acceptable to the NRC staff for satisfying NRC regulations with respect to high functional reliability and design quality requirements for computers used as components of a safety system.

IEEE Std 7-4.3.2-1993, Section 2, references several industry codes and standards. If a referenced standard has been separately incorporated into NRC regulations, licensees and applicants must comply with the standard as set forth in the regulation. If the referenced standard has been endorsed by the NRC staff in a regulatory guide, the standard constitutes an acceptable method of meeting a regulatory requirement as described in the regulatory guide. If a referenced standard has been neither incorporated into NRC regulations nor endorsed in a regulatory guide, licensees and applicants may consider and use the information in the referenced standard if appropriately justified, consistent with current regulatory practice.

YMP Position: Conform with exception

YMP will use IEEE Std 7-4.3.2™-2003 [DIRS 170777].

Regulatory Guidance Document Number: Reg Guide 1.153, Rev. 1 [DIRS 103165]

Regulatory Guidance Title:

CRITERIA FOR SAFETY SYSTEMS

Regulatory Position:

Conformance with the requirements of IEEE Std 603-1991 (including the correction sheet dated January 30, 1995) provides a method acceptable to the NRC staff for satisfying NRC regulations with respect to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of the safety systems of nuclear power plants.

IEEE Std 603-1991, Section 3, references several industry codes and standards. If a referenced standard has been incorporated separately into NRC regulations, licensees and applicants must comply with that standard as set forth in the regulation. If the referenced standard has been endorsed in a regulatory guide, the standard constitutes a method acceptable to the NRC staff of meeting a regulatory requirement as described in the regulatory guide. If a referenced standard has been neither incorporated into NRC regulations nor endorsed in a regulatory guide, licensees and applicants may consider and use the information in the referenced standard if appropriately justified, consistent with current regulatory practice.

YMP Position: Conform with exception

YMP will use IEEE Std 603-1998 [DIRS 125916].

Regulatory Guidance Document Number: Reg Guide 1.165, Rev. 0 [DIRS 119139]

Regulatory Guidance Title:

IDENTIFICATION AND CHARACTERIZATION OF SEISMIC SOURCES AND DETERMINATION OF SAFE SHUTDOWN EARTHQUAKE GROUND MOTION

Regulatory Position:

This guide has been developed to provide general guidance on procedures acceptable to the NRC staff for (1) conducting geological, geophysical, seismological, and geotechnical investigations, (2) identifying and characterizing seismic sources, (3) conducting probabilistic seismic hazard analyses, and (4) determining the safe shutdown earthquakes (SSE) for satisfying the requirements of 10 CFR 100.23.

YMP Position: Conform with exception

The DOE intends to conform to guidance in Regulatory Guide 1.165 [DIRS 119139], Part C, with the following exceptions:

RP 1.1. Not applicable.

RP 1.2. Conform.

RP 1.3. Conform.

RP 1.4. Exception. For situations in which avoidance of faults that are subject to displacement and of sufficient length and are located in such a manner that they may affect repository design and performance cannot be reasonably achieved, SSCs ITS will be designed to accommodate the effects of fault displacement such that the performance objectives of 10 CFR Part 63 [DIRS 173273] are met.

RP 1.5. Conform.

RP 2. Conform.

RP 3(1). Conform.

RP 3(2). Not applicable.

RP 3(3). Conform.

RP 3(4). Exception. The reference probability (1E-5 per year) described in Appendix B of Regulatory Guide 1.165, which applies to SSEs for nuclear power plants, is not used. Rather, reference probabilities that the DOE intends to use to develop seismic inputs for analyses supporting design and performance assessment are established by the technical bases provided in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564]).

Also, the DOE intends to determine the mean, rather than median, spectral ground motion levels for the average of 5 and 10 Hz, Sa, 5-10, and for the average of 1 and 2 Hz, Sa, 1-2. For the lower frequency range, this differs from the average of 1 and 2.5 Hz spectral ground motion levels identified in the guidance.

RP 3(5). Exception. Consistent with the reference probabilities identified in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564]), the DOE intends to deaggregate the mean, rather than median, probabilistic hazard characterization.

RP 4(1). Exception. The DOE will not use the procedures in Revision 3 of the Standard Review Plan, Section 2.5.2, to develop 5 percent of critical damping site-specific response spectral shapes for the controlling earthquakes. Rather, the DOE intends to develop 5 percent of critical damping site-specific response spectral shapes for the controlling earthquakes using the ground motion attenuation relation determined by the ground motion experts who participated in the probabilistic seismic hazard analysis for the Yucca Mountain site.

RP 4(2). Conform.

RP 4(3). Conform, with clarification. Because the control motion for the Yucca Mountain site is defined at a hypothetical reference rock outcrop with dynamic material properties found at a depth of about 300 meters, the location-specific site-response analysis takes into account the effect of rock and soil above the control point. Location-specific ground motions are determined for a free-field site at the location of repository surface facilities and for an interface at the depth of waste emplacement.

RP 4(4). Conform.

Appendix A. Conform. Note that SSE ground motion is not applicable to the design of SSCs of a geologic repository at Yucca Mountain.

Appendix B. Exception. The DOE will not use the reference probability or approach to determining reference probabilities described in Appendix B. Rather, reference probabilities for design and analysis of SSCs of a geologic repository at Yucca Mountain are described, along with their technical basis, in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain* (BSC 2004 [DIRS 170564], but currently being revised).

Appendix C. Exceptions as noted below:

C.2 Step 1. Exception. Probabilistic seismic hazard for the Yucca Mountain site was determined for spectral accelerations of 0.3, 0.5, 1, 2, 5, 10, 20, 100 Hz (peak ground acceleration), and peak ground velocity, rather than 1, 2.5, 5, 10, 25, and peak ground acceleration.

C.2 Step 2. Exception. The reference probability is not determined following the approach of Appendix B. (See exception to Appendix B.) Also, the average ground motion level is determined for the 1 and 2 Hz and 5 and 10 Hz spectral acceleration pairs, not the 1 and 2.5 Hz and 5 and 10 Hz pairs.

C.2 Step 3. Clarification. Deaggregation is carried out with respect to distance, magnitude, and ground motion variability about the median. By also deaggregating about ground motion variability, additional information is provided about a major uncertainty. The additional information can be used to guide development of design ground motions.

C.2 Step 6. Exception. The DOE intends to use the mode magnitude and distance from the deaggregation rather than the mean.

Appendix D. exceptions as noted below:

D.2.1. Exception. Consistent with NUREG-1494 (McConnell and Lee 1994 [DIRS 110957]), the DOE will avoid faults that are subject to displacement and affect repository design or performance where this can be reasonably achieved. If avoidance of such faults cannot be reasonably achieved, the DOE will demonstrate, with reasonable assurance, that any proposed repository designed to accommodate the effects of faulting meets the 10 CFR Part 63 [DIRS 173273] preclosure and postclosure performance objectives.

While the level of detail of seismic investigations that the DOE has carried out is consistent with the guidance provided in D.2.1, the DOE has not formally characterized its investigations in terms of the 320 km, 40 km, and 8 km, and 1 km distances for regional, reconnaissance, detailed, and site investigations, respectively.

Appendix E. Not applicable. This appendix describes how new information should be considered when evaluating the results of the Lawrence Livermore National Laboratory and Electric Power Research Institute probabilistic seismic hazard analyses for the central and eastern United States.

Appendix F. Conform. Note that while this appendix addresses the SSE ground motion for nuclear power plants, its approach can be applied to the development of seismic design inputs for a geologic repository at Yucca Mountain.

Regulatory Guidance Document Number: **Reg Guide 1.168, Rev. 1 [DIRS 168888]**

Regulatory Guidance Title:

VERIFICATION, VALIDATION, REVIEWS, AND AUDITS FOR DIGITAL COMPUTER SOFTWARE USED IN SAFETY SYSTEMS OF NUCLEAR POWER PLANTS

Regulatory Position:

IEEE 1012-1998 provides methods that are acceptable to the NRC staff for meeting the requirements of 10 CFR Part 50 as 1.168-5. They apply to the verification and validation of safety system software, subject to the exceptions listed in these regulatory positions.

The methods in IEEE 1028-1997 provide an approach acceptable to the NRC staff for carrying out software reviews, inspections, walkthroughs, and audits, subject to the exceptions listed below in Regulatory Position 8. These methods are often used in association with software quality assurance activities.

The annexes to IEEE 1012-1998 and IEEE Std 1028-1997 contain information that may be useful, but the information in these annexes should not be viewed as the only possible solution or method. Because a consensus has not been reached in the nuclear industry regarding the use of these methods, these annexes are not endorsed by the NRC staff, except as noted below. In this regulatory position, the cited criteria are in 10 CFR Part 50, Appendix B, unless otherwise noted.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.169, Rev. 0 [DIRS 103176]**

Regulatory Guidance Title:

CONFIGURATION MANAGEMENT PLANS FOR DIGITAL COMPUTER SOFTWARE USED IN SAFETY SYSTEMS OF NUCLEAR POWER PLANTS

Regulatory Position:

IEEE Std 828-1990 provides an approach acceptable to the NRC staff for meeting the requirements of 10 CFR Part 50, as applied to software, planning configuration management of safety system software, subject to the provisions listed.

ANSI/IEEE Std 1042-1987, subject to the provisions listed, provides guidance acceptable to the NRC staff for carrying out software configuration management plans produced under the auspices of IEEE Std 828-1990. ANSI/IEEE Std 1042-1987 should be used with the definitions of IEEE Std 828-1990 to implement the details of plans prepared pursuant to IEEE Std 828-1990. In the provisions listed, reference is made to explanatory sections of ANSI/IEEE Std 1042-1987, where appropriate, to clarify software configuration management concepts.

To meet the cited requirements of 10 CFR Part 50, Appendix A, by complying with the cited criteria of Appendix B, the noted exceptions are necessary and will be considered by the NRC staff in the review of submittals from applicants and licensees. (In this regulatory position, the cited criteria are in 10 CFR Part 50, Appendix B, unless otherwise noted.)

YMP Position: Conform with exception

YMP shall use IEEE Std 828-1998 [DIRS 145986].

Regulatory Guidance Document Number: **Reg Guide 1.170, Rev. 0 [DIRS 103179]**

Regulatory Guidance Title:

SOFTWARE TEST DOCUMENTATION FOR DIGITAL COMPUTER SOFTWARE USED IN SAFETY SYSTEMS OF NUCLEAR POWER PLANTS

Regulatory Position:

The requirements contained in IEEE Std 829-1983 provide an approach acceptable to the NRC staff for meeting the requirements of 10 CFR Part 50 as they apply to the test documentation of safety system software subject to the exceptions listed. The appendices to this standard are not covered by this regulatory guide. (In this regulatory position, the cited criteria are in 10 CFR Part 50, Appendix B, unless otherwise noted.)

YMP Position: Conform with exception

YMP shall use IEEE Std 829-1998 [DIRS 145988].

Regulatory Guidance Document Number: **Reg Guide 1.171, Rev. 0 [DIRS 103181]**

Regulatory Guidance Title:

SOFTWARE UNIT TESTING FOR DIGITAL COMPUTER SOFTWARE USED IN SAFETY SYSTEMS OF NUCLEAR POWER PLANTS

Regulatory Position:

The requirements in ANSI/IEEE Std 1008-1987 provide an approach acceptable to the NRC staff for meeting the requirements of 10 CFR Part 50 as they apply to the unit testing of safety system software, subject to the provisions listed. The appendices to ANSI/IEEE Std 1008-1987 are not endorsed by this regulatory guide except as noted. Appendix A to this standard provides guidance regarding the implementation of the software unit testing approach, and Appendix B to the standard provides context regarding software engineering information and testing assumptions that underlie the software unit testing approach.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.172, Rev. 0 [DIRS 103182]**

Regulatory Guidance Title:

SOFTWARE REQUIREMENTS SPECIFICATIONS FOR DIGITAL COMPUTER SOFTWARE USED IN SAFETY SYSTEMS OF NUCLEAR POWER PLANTS

Regulatory Position:

The recommended practices in IEEE 830-1993 provide an approach that is acceptable to the NRC staff for meeting the requirements of 10 CFR Part 50 as they apply to the preparation of software requirements specifications for safety system software, subject to the exceptions listed.

YMP Position: Conform with exception

The YMP will use IEEE Std 830-1998 [DIRS 125747].

Regulatory Guidance Document Number: **Reg Guide 1.173, Rev. 0 [DIRS 103183]**

Regulatory Guidance Title:

DEVELOPING SOFTWARE LIFE CYCLE PROCESSES FOR DIGITAL COMPUTER SOFTWARE USED IN SAFETY SYSTEMS OF NUCLEAR POWER PLANTS

Regulatory Position:

The requirements contained in IEEE 1074-1995 provide an approach acceptable to the NRC staff for meeting the requirements of 10 CFR Part 50 and the guidance in Regulatory Guide 1.152 as they apply to development processes for safety system software, subject to the provisions listed. The appendices to IEEE 1074-1995 are not endorsed by this regulatory guide.

YMP Position: Conform with exception

YMP will use IEEE Std 1074-1997 [DIRS 169768].

Regulatory Guidance Document Number: Reg Guide 1.180, Rev. 1 [DIRS 171818]

Regulatory Guidance Title:

GUIDELINES FOR EVALUATING ELECTROMAGNETIC AND RADIO-FREQUENCY INTERFERENCE IN SAFETY-RELATED INSTRUMENTATION AND CONTROL

Regulatory Position:

Establishing and continuing an electromagnetic compatibility (EMC) program for safety-related instrumentation and control (I&C) systems in nuclear power plants contribute to the assurance that safety-related SSCs are designed to accommodate the effects of and to be compatible with the environmental conditions associated with nuclear power plant service conditions. Application of consensus standard practices regarding the design, testing, and installation of safety-related I&C system modifications or new installations constitutes an important element of such a program. This guidance recommends design and installation practices to limit the consequences of electromagnetic effects, testing practices to assess the emissions and susceptibility of equipment, and testing practices to evaluate the power surge withstanding capability of the equipment. Operating envelopes characteristic of the electromagnetic environment in nuclear power plants are cited in this guidance as the basis for establishing acceptable testing levels. Table 1 in the regulatory guide lists the specific regulatory positions on EMC that are set forth below. This guidance is applicable to all new safety-related systems or modifications to existing safety-related systems that include analog, digital, or hybrid (i.e., combined analog and digital) electronics equipment. The endorsed test methods for evaluating the electromagnetic emissions, electromagnetic interference (EMI)/radio frequency interference (RFI) susceptibility, and power surge withstand capability of safety-related equipment are intended for application in test facilities or laboratories before installation.

To ensure that the operating envelopes are being used properly, equipment should be tested in the same physical configuration as that specified for its actual installation in the nuclear power plant. In addition, the equipment should be in its normal mode of operation (i.e., performing its intended function) during the testing. Following the tests, the physical configuration of the safety-related I&C system should be maintained and all changes in the configuration controlled. The design specifications that should be maintained and controlled include wire and cable separations, shielding techniques, shielded enclosure integrity, apertures, gasketing, grounding techniques, EMI/RFI filters, circuit board layouts, and other design parameters that may affect the EMC qualification testing results.

Exclusion zones should be established through administrative controls to prohibit the activation of portable EMI/RFI emitters (e.g., welders and transceivers) in areas where safety-related I&C systems have been installed. An exclusion zone is defined as the minimum distance permitted between the point of installation and where portable EMI/RFI emitters are allowed to be activated. The size of the exclusion zones should be site-specific and depend on the effective radiated power and antenna gain of the portable EMI/RFI emitters used within a particular nuclear power plant.

IEEE Std 1050-1996 describes design and installation practices that are acceptable to the NRC staff regarding EMI/RFI and power surge-related effects on safety-related I&C systems employed in nuclear power plants with the following exception.

Section 4.3.7.4 of the standard maintains that the "field strength" of propagating electromagnetic waves is inversely proportional to the square of the distance from the source of radiation. This statement needs to be reevaluated because radiative coupling is a farfield effect. A distance, r, greater than the wavelength divided by 2π ($r > \lambda/2\pi$) from the source of radiation is considered to be far field, which is the region where the wave impedance is equal to the characteristic impedance of the medium. The electric and magnetic "field strengths" fall off as $1/r$ in the far field (i.e., in inverse proportion to distance; not as its square). This concept is not to be confused with the propagation of electromagnetic waves in the near field ($r < \lambda/2\pi$) where the wave impedance is determined by the characteristics of the source and the distance from the source. In the near field, if the source impedance is high ($>377\Omega$), the electric and magnetic "field strengths" attenuate at rates of $1/r^3$ and $1/r^2$, respectively. If the source impedance is low ($<377\Omega$), the rates of attenuation are reversed: the electric "field strength" will fall off at a rate of $1/r^2$ and the magnetic "field strength" at a rate of $1/r^3$.

The user should understand that radiative coupling is a far-field effect and the "field strength" falls off as $1/r$, not as $1/r^2$.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 1.189, Rev. 0 [DIRS 155040]**

Regulatory Guidance Title:

FIRE PROTECTION FOR OPERATING NUCLEAR POWER PLANTS

Regulatory Position:

This regulatory guide has been developed to provide a comprehensive fire protection guidance document and to identify the scope and depth of fire protection that the staff would consider acceptable for nuclear plants currently operating as of January 1, 2001. This guide may be used for licensee self-assessments and as the deterministic basis for future rulemaking. Risk-informed and performance-based alternatives to the guidance presented in this regulatory guide may be acceptable to the NRC staff.

YMP Position: Conform with exception

Explanation of exception will be added later.

Regulatory Guidance Document Number: Reg Guide 3.18, Rev. 0 [DIRS 158804]

Regulatory Guidance Title:

CONFINEMENT BARRIERS AND SYSTEMS FOR FUEL REPROCESSING PLANTS

Regulatory Position:

This guide describes bases acceptable to the NRC staff for the design of confinement barriers for fuel reprocessing plants. In order to limit the spread of radioactive materials, reprocessing facilities are separated into zones of potential contamination. Barriers regulate the direction of air or gas flow between zones so that leakage is from zones of low potential for contamination to zones for higher potential for contamination.

10 CFR Part 20, Section 20.1, states that licensees should make every reasonable effort to maintain radiation exposure and the release of radioactive materials in effluents to unrestricted areas, as far below the limits specified in that part as practible. Properly designed confinement barriers provide a principal means of reducing such exposures and releases.

The regulatory position is subdivided as follows:

1. Barriers are provided.
2. Barriers are designed to withstand design basis events.
3. Pentrating pipes would have an isolation valve.
4. Confinement zones are established by confinement barriers.
5. Barriers are designed to withstand differential pressures.
6. Barriers prevent leakage of contaminated fluids.
7. Barriers are monitored for gases and liquids and alarmed accordingly.
8. Barriers are constructed of non-flammable materials.

YMP Position: Conform with exception

Regulatory Guide 3.18 is used as a design guide for subsurface ventilation system isolation barriers.

The subsurface repository stores sealed waste packages and is not considered a fuel reprocessing facility; however, there is potential contamination on the outside of waste packages and air ionization as the air moves through the emplacement drifts. The subsurface ventilation system is classified as non-ITS, non-ITWI, and non-SC, and the development side of the repository is an uncontrolled area from a nuclear radiation standpoint. The subsurface repository includes isolation barriers between the emplacement and development areas, and it is reasonable to apply the Regulatory Guide 3.18 barrier design criteria to the subsurface isolation barriers.

Regulatory Guidance Document Number: **Reg Guide 3.20, Rev. 0 [DIRS 171701]**

Regulatory Guidance Title:

PROCESS OFFGAS SYSTEMS FOR FUEL REPROCESSING PLANTS

Regulatory Position:

1. All parts of the process offgas system should be designed:

   To limit the release of radioactive materials during normal operation to the levels stated in 10 CFR Part 20.

   To limit the release of noxious materials to comply with federal and state statutes and implementing regulations imposed by federal, state, and regional agencies.

   To withstand postulated accident conditions to the extent that the uncontrolled release of radioactive material to the environs is prevented or to be enclosed within a structure designed to withstand postulated accident conditions to the same extent. Accident conditions postulated should include earthquake, tornado, equipment and utility failure, and engineering or operating error. The pertinent quality assurance requirements of 10 CFR Part 50, Appendix B, should be applied to all activities affecting the safety-related functions of these SSCs.

   With adequate duplicate process and support equipment to maintain system safety functions in the event of any single failure or during maintenance operations.

   To resist fire, thermal, effects, and the corrosive effects of cell atmospheres, decontamination solutions, and collected gases to the extent necessary to maintain safety-related functions.

   To permit inspection, maintenance, and testing of systems and components that have safety-related functions to ensure their continued functioning for the life of the facility.

2. The gas collection equipment should be designed to:

   Collect gases near points of generation and conduct them in closed piping systems to treatment systems for the removal of hazardous chemical or radioactive materials.

   Operate at negative pressures relative to surrounding cells where practical.

Prevent header flooding and unsafe accumulation of fissionable materials by sloping collection piping to drain to appropriate process vessels by the use of condensers, knockout pots, and vessel overflow lines

Minimize entrainment into collection headers, thereby preventing unsafe accumulation of fissionable materials, sizing vessel offgas lines to provide low gas velocities, providing deentrainment devices, and separating vessel offgas lines from other vessel lines such as those receiving jet or pump discharge streams.

Limit spread of contamination by preventing backflows from radioactive to less radioactive areas by use of liquid seals on cold chemical addition lines, providing top entry of offgas branch lines into headers, and providing pressure-relief devices to guard against pressure increases due to flow blockages or gas flows in excess of design specifications.

Minimize radiation exposure to plant personnel by locating process piping containing radioactive material away from areas frequently occupied by plant personnel or providing local biological shielding.

3. The chemical treatment equipment should be designed to:

   Remove radioactive and noxious gaseous contaminants predictably and effectively from process offgases. These contaminants include iodine, organic and inorganic iodine specks, and other hazardous materials.

   Provide protection to zeolite adsorbers against moisture damage.

4. The particulate removal equipment should be designed to:

   Remove radioactive particulate contaminants predictably and effectively from process offgas.

   Resist fire and be located downstream from fire-suppressing process devices or be equipped with fire detection and extinguishing devices. Fire-suppressing devices may consist of other process units, such as wet scrubbers used for chemical treatment, or may be systems designed specifically for fire protection.

   Resist or be protected from condensate damage by maintaining system temperatures above the dewpoint of the gas and providing low-point traps and drains on supply headers.

5. The exhaust equipment should be designed:

   To provide motive power adequate to overcome offgas system head and maintain prescribed offgas system pressures to prevent backflow of contaminated gases into potentially inhabited areas.

   With emergency utilities provided automatically on failure of prime utility source.

6. The sampling and chemical monitoring equipment should provide:

   Sampling points for offgas on each chemical removal device and at the process offgas system inlet and discharge points.

   Ports for testing filter efficiency on each safety-related stage of filtration.

   Redundant continuous monitoring devices adequate to measure and record overall effluent radioactivity and system performance at point of process offgas system discharges to the environs. These devices may be stack monitors that monitor combined plant discharges.

   Alarms in a continuously occupied control room to indicate safety-related abnormal conditions.

7. Control and instrumentation systems should be designed to:

   Control automatically or facilitate manual control of all safety-related process parameters.

   Indicate or record all safety-related process parameters in a regularly occupied control room. Parameters include such items as fluid levels, pressures, temperatures, and radiation levels.

   Alarm all abnormal safety-related parameters in a continuously occupied control room.

   Switch in safety-related standby process devices automatically when needed.

   Switch safety-related process devices to standby power supplies automatically when needed.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 3.32, Rev. 0 [DIRS 103310]**

Regulatory Guidance Title:

GENERAL DESIGN GUIDE FOR VENTILATION SYSTEMS FOR FUEL REPROCESSING PLANTS

Regulatory Position:

This guide describes bases acceptable to the NRC staff for the design of ventilation systems for fuel reprocessing plants. At fuel reprocessing plants, a principal risk to health and safety is the uncontrolled release and dispersal of airborne radioactive material. SSCs ITS in a fuel reprocessing plant include, among other things, features designed to prevent, limit, or mitigate the release of radioactive material. These features include protection by multiple confinement barriers and systems, ventilation systems, and offgas systems.

Ventilation systems for a fuel reprocessing plant should ensure the confinement of hazardous materials during normal or abnormal conditions, including natural phenomena, fire, and explosion. The release of radioactive material to the environment or to an area in which levels of radioactivity are normally sufficiently low to permit personnel access should be reduced to a level as low as practicable in accordance with 10 CFR Part 20.

The regulatory position is subdivided as follows:

- C.1 General safety
- C.2 Occupied area ventilation system
- C.3 Process area ventilation systems
- C.4 Exhaust ventilation and filtration systems
- C.5 Fans
- C.6 Ventilation system construction and layout
- C.7 Ventilation system testing and monitoring
- C.8 Quality assurance program.

YMP Position: Conform with exception

Regulatory Position C.4.a.9—The design of the HEPA filters will use ASME AG-1-2003 [DIRS 166908] instead of the referenced MIL-F-51068D and MIL-F-51079B.

C.4.a.10—The DOE-HDBK-1169-2003 [DIRS 167097] will be used as a guidance document instead of the referenced ORNL/NSIC-65, *Design, Construction and Testing of High-Efficiency Air Filtration Systems for Nuclear Applications.* The DOE-HDBK-1169-2003 succeeds three previous editions of the Nuclear Air Cleaning Handbook: ERDA 76-21, *Nuclear Air Cleaning Handbook* (1976); ORNL/NSIC-65, *Design, Construction and Testing of High-Efficiency Air Filtration Systems for Nuclear Applications* (1970); and NSIC-13, *Filters, Sorbents, and Air Cleaning Systems as Engineered Safeguards in Nuclear Installations* (1966). This DOE-HDBK-1169-2003 [DIRS 167097] updates the information provided in ERDA 76-21 and incorporates current thinking as provided by manufacturers, subject matter experts from the DOE complex and members of the ASME AG-1 [DIRS 166908] Committee.

Regulatory Guidance Document Number: Reg Guide 3.71, Rev. 0 [DIRS 103299]

Regulatory Guidance Title:

NUCLEAR CRITICALITY SAFETY STANDARDS FOR FUELS AND MATERIAL FACILITIES

Regulatory Position:

Most of the ANSI/ANS-8 nuclear criticality safety standards have been endorsed by NRC in other regulatory guides. This regulatory guide consolidates and replaces the following regulatory guides without altering any existing licensing commitments or introducing any new requirements. Regulatory Guides 3.1, 3.4, 3.43, 3.45, 3.47, 3.57, 3.58, 3.68, 3.70, and 8.12 are, therefore, being withdrawn.

YMP Position: Conform with exception

Explanation of exception will be added later.

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 3.73, Rev. 0 [DIRS 172763]

Regulatory Guidance Title:

SITE EVALUATIONS AND DESIGN EARTHQUAKE GROUND MOTION FOR DRY CASK INDEPENDENT SPENT FUEL STORAGE AND MONITORED RETRIEVABLE STORAGE INSTALLATIONS

Regulatory Position:

This guide provides general guidance on procedures acceptable to the NRC staff for: (1) conducting a detailed evaluation of site area geology and foundation stability; (2) conducting investigations to identify and characterize uncertainty in seismic sources in the site region important for the PSHA; (3) evaluating and characterizing uncertainty in the parameters of seismic sources; (4) conducting PSHA for the site; and (5) determining the DE to satisfy the requirements of Part 72.

This guide contains several appendices that address the objectives stated above. Appendix A contains definitions of pertinent terms. Appendix B discusses determination of the probabilistic ground motion level and controlling earthquakes and the development of a seismic hazard information base, Appendix C discusses site-specific geological, seismological, and geophysical investigations. Appendix D describes a method to confirm the adequacy of existing seismic sources and source parameters as the basis for determining the DE for a site. Appendix E describes procedures for determination of the DE.

This guide applies to the design basis of both dry cask storage Independent Spent Fuel Storage Installations (ISFSIs) and DOE monitored retrievable storage (MRS) installations, because these facilities are similar in design.

YMP Position: Conform with exception

The YMP conforms with exception to Regulatory Guide 3.73. This regulatory guide specifies the design basis ground motions for independent spent fuel storage facilities as the ground motion associated with a mean annual probability of exceedance of 5×10^{-4}. The Yucca Mountain Repository surface and subsurface nuclear facilities are designed with no high pressure or high temperature systems (common to nuclear power plants) whose failure could lead to active dispersal of radionuclides. Therefore, DOE has concluded that the risk significance of the Yucca Mountain preclosure facilities is less than nuclear power plants and comparable to that of spent nuclear fuel storage facilities. Accordingly, DOE has concluded that the use of DBGM-1 and DBGM-2 ground motion levels for the design of surface and subsurface SSCs important to safety is reasonable and appropriate.

The YMP will follow the guidance provided in Reg. Guide 1.165 for the balance of the guidance provided in this Reg. Guide.

Regulatory Guidance Document Number: Reg Guide 4.1, Rev. 1 [DIRS 105993]

Regulatory Guidance Title:

PROGRAMS FOR MONITORING RADIOACTIVITY IN THE ENVIRONS OF NUCLEAR POWER PLANTS

Regulatory Position:

The program for monitoring radioactivity in the environs of nuclear power plants should provide suitable information from which levels of radiation and radioactivity in the environs of each plant can be estimated.

YMP Position: Conform with exception

The Regulatory Guide 4.1 requires that licensees provide means for monitoring the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.

The only exception is that it generates requirements from 10 CFR Part 50 [DIRS 165855] whereas YMP is subject to 10 CFR Part 63 [DIRS 173273].

Regulatory Guidance Document Number: Reg Guide 5.7, Rev. 1 [DIRS 103534]

Regulatory Guidance Title:

ENTRY/EXIT CONTROL FOR PROTECTED AREAS, VITAL AREAS, AND MATERIAL ACCESS AREAS

Regulatory Position:

Part 73, "Physical Protection of Plants and Materials," of Title 10, Code of Federal Regulations, specifies performance requirements for the physical protection of special nuclear materials and associated facilities. Section 73.20, "General Performance Requirements," describes the general performance objective and requirements that must be met through the establishment of a physical protection system. Performance capabilities necessary to meet the requirements of § 73. 20 are described in § 73.45, "Performance Capabilities for Fixed Site Physical Protection Systems." While detection and control requirements are specified throughout the capability statements, specific entry/exit control techniques are required under three capabilities. Paragraph 73.45(b) specifies preventing unauthorized access of persons, vehicles, and materials into material access areas and vital areas. A physical protection system must achieve this by using entry controls, among other things. Paragraph 73.45(e) permits "removal of only authorized and confirmed forms and amounts of strategic special nuclear material from material access areas." The system must achieve this capability by providing detection subsystems and procedures to detect, assess, and communicate attempts at unauthorized removal. Paragraph 73.45(f) provides for ensuring only authorized access to the protected area and requires, in part, the use of entry controls to meet the capability. Finally, § 73.46, "Fixed Site Physical Protection Systems, Subsystems, Elements, Components, and Procedures," outlines typical specific safeguards measures that will often be included in an overall system that meets the requirements of Sections 73.20 and 73.45.

A significant element of the physical protection system is the control of the entry and exit of personnel, vehicles, and material. This control includes personnel identification and entry/exit control systems and procedures for searching individuals, vehicles, and materials. Entry and exit control procedures are used to provide assurance that only authorized individuals are allowed access to protected areas (PAs), vital areas (VAs), and material access areas (MAAs). Entry search procedures, in conjunction with other protection elements, are used to provide assurance that firearms, explosives, and incendiary devices are not introduced into the subject areas. Exit search procedures from material access areas are used to provide assurance that strategic special nuclear material (SSNM) is not being covertly removed.

This guide describes measures the NRC staff considers acceptable for implementing entry/exit control requirements at facilities subject to the above regulatory requirements.

YMP Position: Conform

Regulatory Guidance Document Number: Reg Guide 5.12, Rev. 0 [DIRS 158856]

Regulatory Guidance Title:

GENERAL USE OF LOCKS IN THE PROTECTION AND CONTROL OF FACILITIES AND SPECIAL NUCLEAR MATERIALS

Regulatory Position:

Locks are acceptable devices to be used in adhering to the physical protection requirements previously identified to assist in controlling access to areas, facilities, and materials through doors, gates, container lids, and similar material or personnel access points, and are considered essential components of a physical barrier. This guide provides criteria acceptable to the regulatory staff for the selection and use of commercially available locks in the protection of facilities and special nuclear material (SNM).

YMP Position: Conform

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 5.26, Rev. 1 [DIRS 103532]

Regulatory Guidance Title:

SELECTION OF MATERIAL BALANCE AREAS AND ITEM CONTROL AREAS

Regulatory Position:

Licensees authorized to possess more than one effective kilogram of special nuclear materials are required to establish Material Balance Areas (MBAs) or Item Control Areas (ICAs) for the physical and administrative control of nuclear materials.

YMP Position: Conform with exception

Material inventory will not be subjected to measurements. Instead item accounting will be relied upon to account for and control nuclear material. Material balance areas will be used for conducting annual physical inventories, while item control areas will be utilized in continuous, day-to-day item control operations.

Regulatory Guidance Document Number: Reg Guide 5.27, Rev. 0 [DIRS 165827]

Regulatory Guidance Title:

SPECIAL NUCLEAR MATERIAL DOORWAY MONITORS

Regulatory Position:

10 CFR Part 73, Paragraph (b) of Section 73.60, requires that individuals exiting from material access areas be searched for concealed SNM. This guide describes means acceptable to the regulatory staff for employing SNM doorway monitors to comply with that requirement.

YMP Position: Conform with exception

This GROA design will not include material access areas but instead will use item control areas.

Regulatory Guidance Document Number: Reg Guide 5.44, Rev. 3 [DIRS 158857]

Regulatory Guidance Title:

PERIMETER INTRUSION ALARM SYSTEMS

Regulatory Position:

This guide describes the functions of perimeter intrusion detection sensors and detection methods that are acceptable to the NRC staff for meeting the portions of the NRC regulation specified in 10 CFR Part 73.

YMP Position: Conform

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 5.49, Rev. 0 [DIRS 165832]

Regulatory Guidance Title:

INTERNAL TRANSFERS OF SPECIAL NUCLEAR MATERIAL

Regulatory Position:

There shall be control of internal transfer of special nuclear material. This guide sets forth acceptable methods for controlling and documenting transfers of SNM within a plant site in order to meet the requirements. Regulatory guide positions are specified for the following:

C.1 Control of internal transfers of SNM
C.2 Internal material transfer tickets
C.3 Measurement of internally transfered materials

YMP Position: Conform with exception

This regulatory guide discusses acceptable methods for controlling and documenting transfer of SNM within a facility. The GROA will conform to Regulatory Positions C.1 and C.2 on the basis that these positions can provide guidance to develop an internal transfer procedure suitable to satisfy 10 CFR 63.78. C.3 is not applicable to the GROA because no independent onsite measurements of the internal transfers will be necessary (i.e., the GROA will use an item control and accounting approach and appropriate tamper-indicating devices or other means to ensure the integrity of SNM content determined at a shipper level).

Regulatory Guidance Document Number: Reg Guide 5.52, Rev. 3 [DIRS 167366]

Regulatory Guidance Title:

STANDARD FORMAT AND CONTENT OF A LICENSEE PHYSICAL PROTECTION PLAN FOR STRATEGIC SPECIAL NUCLEAR MATERIAL AT FIXED SITES (OTHER THAN NUCLEAR POWER PLANTS)

Regulatory Position:

The regulatory guide describes the standard format and content recommended for preparing physical protection plans for formula quantities of special nuclear material.

YMP Position: Conform with exception

The GROA will conform to the guidance that is applicable to 10 CFR 73.51 [DIRS 173379] for SNF and HLW pursuant to 10 CFR 63, specifically excepting the provisions of Section C.2 and C.3 of the guide.

Regulatory Guidance Document Number: Reg Guide 5.61, Rev. 0 [DIRS 165838]

Regulatory Guidance Title:

INTENT AND SCOPE OF THE PHYSICAL PROTECTION UPGRADE RULE REQUIREMENTS FOR FIXED SITES

Regulatory Position:

This guide is intended to provide a broad overview of the structure of the Physical Protection Upgrade Rule as it applies to fixed sites and the purpose of its major provisions.

YMP Position: Conform

This guide provides information to assist in understanding the physical security requirements for fuel cycle facilities set forth in 10 CFR Part 73 [DIRS 173379]. The Physical Protection Upgrade Rule is structured in three distinct levels; two are essentially performance-oriented and the third, a safeguard related reference physical protection system, is specification oriented.

Regulatory Guidance Document Number: Reg Guide 5.62, Rev. 1 [DIRS 165839]

Regulatory Guidance Title:

REPORTING OF SAFEGUARDS EVENTS

Regulatory Position:

This guide was prepared to provide guidance on meeting the requirements of 10 CFR 73.71, for reporting safeguard and related events to the NRC. Accordingly the reporting of such safeguards events to the NRC must be consistent with the criteria in 10 CFR Part 73, Appendix G.

YMP Position: Conform

This guide is applicable as guidance associated with security system failures, event logs, and communication means of reporting.

Regulatory Guidance Document Number: Reg Guide 5.65, Rev. 0 [DIRS 158858]

Regulatory Guidance Title:

VITAL AREA ACCESS CONTROLS, PROTECTION OF PHYSICAL SECURITY EQUIPMENT, AND KEY AND LOCK CONTROLS

Regulatory Position:

The NRC's principal requirements with respect to the protection of items of vital equipment at nuclear power reactors are contained in 10 CFR Part 73, "Physical Protection of Plants and Materials." These requirements are aimed at safeguarding against sabotage that could cause a radiological release. The Commission has published amendments to 10 CFR Part 73, 73.55 and

73.70, that clarify safeguards policy for power reactors on control of access to vital areas during emergency and nonemergency situations, protection of certain physical security equipment, and key and lock controls. These revised requirements were developed to clarify or modify certain existing physical protection requirements. The amendments were designed to foster plant safety while maintaining adequate safeguards. This guide presents approaches that are acceptable to the NRC staff for implementing the amendments. Emphasis in the guide is on minimizing the safeguards impact on safety.

YMP Position: Conform

Regulatory Guidance Document Number: Reg Guide 5.68, Rev. 0 [DIRS 167365]

Regulatory Guidance Title:

PROTECTION AGAINST MALEVOLENT USE OF VEHICLES AT NUCLEAR POWER PLANTS

Regulatory Position:

A vehicle barrier system that is capable of preventing forced access of a land vehicle to gain proximity to vital areas should be established at each nuclear power reactor site. The vehicle barrier system should provide a perimeter around vital areas of the facility such that no location along the perimeter would permit forced entry of a land vehicle. The vehicle barrier system, regardless of the type of barriers used, should be of a design capable of stopping the forward motion of the design basis land vehicle. The vehicle barrier system may be incorporated as part of the protected area perimeter system but should not diminish or remove any requirements established for the protected area.

YMP Position: Conform

The requirements of this guide are directly relevant to the GROA. The GROA will be required to provide similar types of physical protection measures against the malevolent use of vehicles at the protected area boundary.

Regulatory Guidance Document Number: Reg Guide 8.05, Rev. 1 [DIRS 106074]

Regulatory Guidance Title:

CRITICALITY AND OTHER INTERIOR EVACUATION SIGNALS

Regulatory Position:

The characteristics of an immediate evacuation signal described in ANSI/ANS-N2.3-1979, *Immediate Evacuation Signal for Use in Industrial Installations*, are generally acceptable to the NRC for use wherever such a system may be needed or required, except that the minimum duration of the signal should be sufficient to ensure evacuation and permit implementation of access control.

YMP Position: Conform

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 8.8, Rev. 3 [DIRS 103312]

Regulatory Guidance Title:

INFORMATION RELEVANT TO ENSURING THAT OCCUPATIONAL RADIATION EXPOSURES AT NUCLEAR POWER STATIONS WILL BE AS LOW AS IS REASONABLY ACHIEVABLE

Regulatory Position:

The goals of the effort to maintain occupational radiation exposures ALARA are (1) to maintain the annual dose to individual station personnel as low as reasonably achievable and (2) to keep the annual integrated (collective) dose to station personnel (i.e., the sum of annual doses [expressed in man-rems] to all station personnel) ALARA.

The NRC staff believes that the stated objectives are attainable with current technology and good operating practices. The costs for attaining these objectives have not been established and are expected to vary widely depending on the features of the specific power reactor facility and the method select to accomplish these objectives. The favorable cost-benefit ration for achieving some of these objectives may be obvious without a detailed study. For other objectives, however, a cost-benefit study might be required to determine whether the objectives are reasonably achievable. Doses to station personnel can affect station availability, and this factor should be considered in assessing the cost-benefit ratio.

Attaining the following objective to the extent practicable throughout the planning, designing, constructing, operating, maintenance, and decommissioning of an LWR station will be considered to provide reasonable assurance that exposures of station personnel to radiation will be ALARA. The methods are deliberately stated such that considerable flexibility can be used in the manner by which the objectives can be achieved. Differences among stations might necessitate further innovation in methods used to achieve the objectives.

YMP Position: Conform

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 8.10, Rev. 1-R [DIRS 103368]

Regulatory Guidance Title:

OPERATING PHILOSOPHY FOR MAINTAINING OCCUPATIONAL RADIATION EXPOSURES AS LOW AS IS REASONABLY ACHIEVABLE

Regulatory Position:

Two basic conditions are considered necessary in any program for keeping occupational exposures as far below the specified limits as is reasonably achievable. The management of the licensed facility should be committed to maintaining exposures ALARA, and the personnel responsible for radiation protection should be continually vigilant for means to reduce exposures.

YMP Position: Conform

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

Regulatory Guidance Document Number: Reg Guide 8.19, Rev. 1. [DIRS 148894]

Regulatory Guidance Title:

OCCUPATIONAL RADIATION DOSE ASSESSMENT IN LIGHT-WATER REACTOR POWER PLANTS DESIGN STAGE MAN-REM ESTIMATES

Regulatory Position:

The objective of this guide is to describe a method acceptable to the NRC staff for performing an assessment of collective occupational radiation dose as part of the ongoing design review process involved in designing a light-water-cooled power reactor so that occupational radiation exposures will be ALARA.

The guide describes the format and content for assessments of the total annual occupational (man-rem) dose at an LWR—principally at the design stage. The dose assessment at this stage should include estimated annual personnel exposures during normal operation and during anticipated operational occurrences.

YMP Position: Conform with exceptions

The YMP conforms with the intent of this guide to develop occupational dose assessments for the facilities that handle, store, or move SNF and HLW. The dose assessments will provide detailed breakdown of the high dose tasks as they are defined for each design phase. The dose assessments identify high dose activities that warrant further ALARA evaluation to further reduce collective dose.

Exceptions:

The regulatory guide generates its requirement from 10 CFR Part 50 [DIRS 165855] whereas YMP is subject to 10 CFR Part 63 [DIRS 173273].

The tables included as attachment include more detail than is available for various design stages, such as preliminary design, and some of the table items will not be present in the YMP facility designs since the guide was developed for light-water-cooled nuclear power plants.

Regulatory Guidance Document Number: **Reg Guide 8.25, Rev. 1 [DIRS 106172]**

Regulatory Guidance Title:

AIR SAMPLING IN THE WORKPLACE

Regulatory Position:

This guide provides recommendations on air sampling to meet the 10 CFR Part 20 requirements.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 8.34, Rev. 0 [DIRS 103658]**

Regulatory Guidance Title:

MONITORING CRITERIA AND METHODS TO CALCULATE OCCUPATIONAL RADIATION DOSES

Regulatory Position:

This guide provides criteria acceptable to the NRC staff that may be used by licensees to determine when monitoring is required, and it describes methods acceptable to the NRC staff for calculating occupational doses when the intake is known. Guidance on calculating doses to the embryo/fetus is contained in Regulatory Guide 8.36, *Radiation Dose to the Embryo/Fetus*.

The positions discussed in Section C of this guide are:

- C.1 Monitoring Criteria
- C.2 Determination of External Doses
- C.3 Calculation of Committed Effective Dose Equivalent from Inhalation
- C.4 Calculation of Committed Effective Dose Equivalent Due to Ingestion
- C.5 Determination of Organ-Specific Committed Dose Equivalents
- C.6 Doses from Intakes Through Wounds or Absorption through Skin
- C.7 Recording of Individual Monitoring Results.

YMP Position: Conform

Regulatory Guidance Document Number: **Reg Guide 8.38, Rev. 0 [DIRS 106181]**

Regulatory Guidance Title:

CONTROL OF ACCESS TO HIGH AND VERY HIGH RADIATION AREAS OF NUCLEAR PLANTS

Regulatory Position:

Licensees are required by 10 CFR 20.1101 to develop and implement a radiation protection program appropriate to the potential radiation hazards in their facility. Specific requirements applicable to controlling access to high radiation areas are in 10 CFR 20.1601, and to very high radiation areas are in 10 CFR 20.1602. This regulatory guide describes methods acceptable to the NRC staff for implementing these requirements.

YMP Position: Conform

Included in Yucca Mountain Review Plan (NRC 2003 [DIRS 163274])

DOE DIRECTIVES

Applicable DOE orders, manuals, guides, and handbooks related to Engineering Design are listed in Table A-2 with only a suggested conformance status. Exceptions to the conformance will be documented in detail in a later revision.

Table A-2. Summary List of Applicable DOE Directives and YMP Positions

DOE Order No.	Title	YMP Position	
		Conform	**Conform with Exception**
DOE G 420.1-1. 2000 [DIRS 159667]	Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for Use with DOE O 420.1, Facility Safety		X
DOE G 440.1-5. 1995 [DIRS 144423]	Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety Program		X
DOE HQ O 250.1. 1998 [DIRS 159140]	Civilian Radioactive Waste Management Facilities—Exemption from Departmental Directives	X	
DOE O 252.1. 1999 [DIRS 159139]	Technical Standards Program	X	
DOE O 413.3. 2000 [DIRS 152047]	Program and Project Management for the Acquisition of Capital Assets	X	
DOE O 420.1A. 2002 [DIRS 159450]	Facility Safety	X	
DOE O 430.2A. 2002 [DIRS 158913]	Departmental Energy and Utilities Management	X	
DOE O 440.1A. 1998 [DIRS 102288]	Worker Protection Management for DOE Federal and Contractor Employees	X	
DOE O 450.1. 2003 [DIRS 161567]	Environmental Protection Program	X	
DOE-HDBK-1140-2001 [DIRS 170491]	Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance		X
DOE-HDBK-1169-2003 [DIRS 167097]	Nuclear Air Cleaning Handbook		X
DOE-STD-1020-2002. 2002 [DIRS 159258]	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities		X
DOE-STD-1027-92. 1992 [DIRS 150357]	Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports		X
DOE-STD-1066-99. 1999 [DIRS 154954]	Fire Protection Design Criteria		X
DOE-STD-1090-2001. [DIRS 169284]	Hoisting and Rigging (Formerly Hoisting and Rigging Manual)		X
DOE-STD-3020-97. 1997 [DIRS 161223]	Specification for HEPA Filters Used by DOE Contractors		X

Table A-2. Summary List of Applicable DOE Orders and YMP Positions (Continued)

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APPENDIX B

TECHNICAL POSITIONS FOR NON-USE OF YUCCA MOUNTAIN REVIEW PLAN CODES AND STANDARDS AND REGULATORY GUIDANCE DOCUMENTS

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APPENDIX B

TECHNICAL POSITIONS FOR NON-USE OF YUCCA MOUNTAIN REVIEW PLAN CODES AND STANDARDS AND REGULATORY GUIDANCE DOCUMENTS

1. ACI 359 1992, *Code for Concrete Reactor Vessels and Containment* [DIRS 158954]

   To be developed in a revision to the PDC.

2. ANSI/ANS-15.17 1981, *Fire Protection Program Criteria for Research Reactors* [DIRS 158949]

   To be developed in a revision to the PDC.

3. Regulatory Guide 1.120, Fire Protection Guidelines for Nuclear Power Plants. Revision 1.

   This regulatory guide has been replaced by Regulatory Guide 1.189, Fire Protection for Operating Nuclear Power Plants [DIRS 155040].

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